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MINERAL RESOURCES OF MICHIGAN

WITH

STATISTICAL TABLES OF PRODUCTION  
AND VALUE OF MINERAL PRODUCTS

FOR

1913 AND PRIOR YEARS

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MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY.

**Publication 16.**  
**Geological Series 13.**

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**MINERAL RESOURCES OF MICHIGAN**  
**WITH**  
**STATISTICAL TABLES OF PRODUCTION**  
**AND VALUE OF MINERAL PRODUCTS**  
**FOR**  
**1913 AND PRIOR YEARS.**

PREPARED UNDER THE DIRECTION OF

**R. C. ALLEN**

DIRECTOR, MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY



PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE BOARD OF  
GEOLOGICAL AND BIOLOGICAL SURVEY FOR 1913.

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LETTER OF TRANSMITTAL.

*To the Honorable, the Board of Geological and Biological Survey of the  
State of Michigan:*

Gov. Woodbridge N. Ferris, President.  
Hon. Wm. J. McKone, Vice-President.  
Hon. Fred L. Keeler, Secretary.

Gentlemen:—Under authority of act number seven, Public Acts of Michigan, Session of 1911, I have the honor to present herewith Publication 16, Geological Series 13, the third of a series of annual statements of the production and value of the mineral products of Michigan.

Very respectfully,  
R. C. ALLEN,  
*Director.*



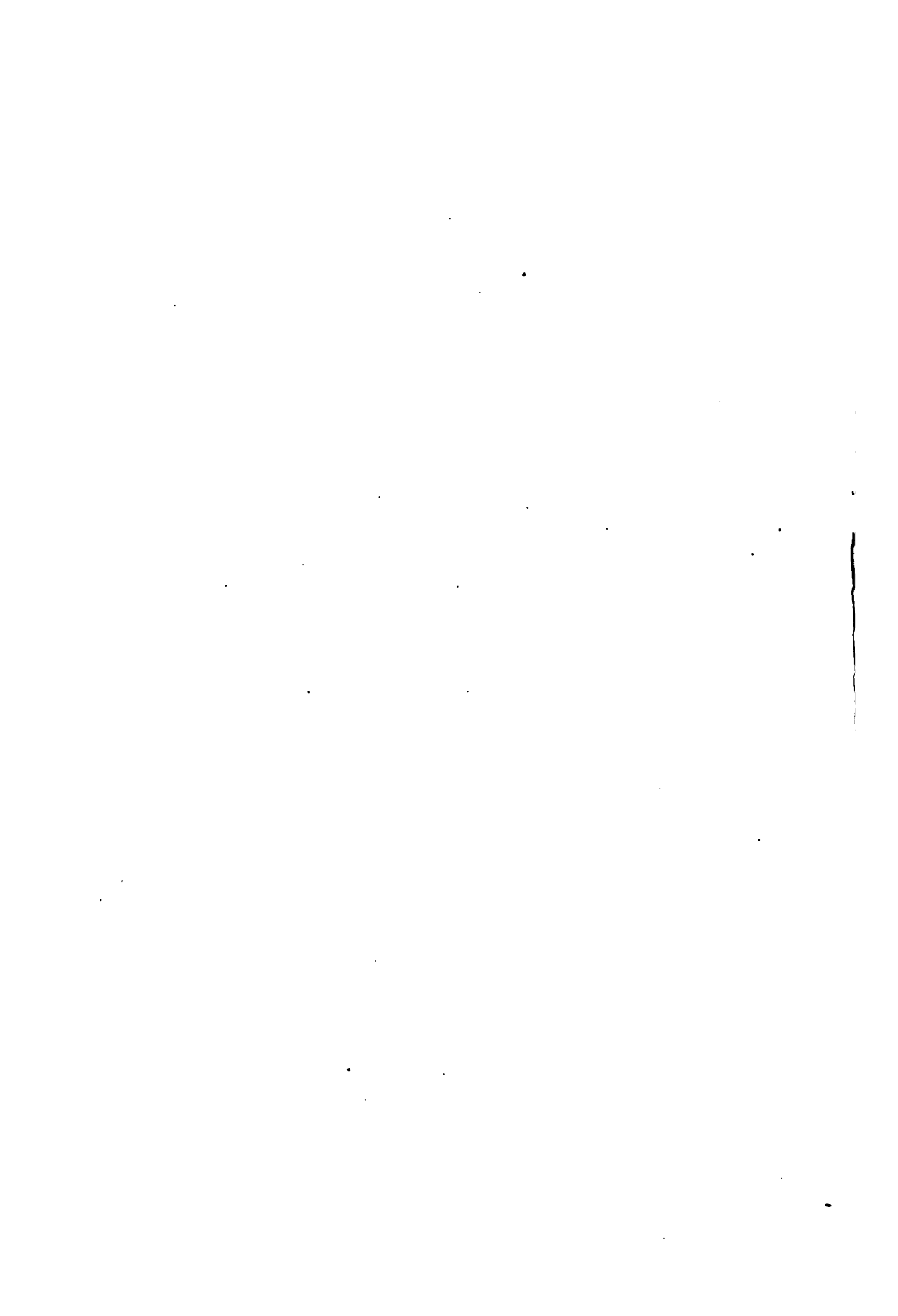
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**PART I.**

**METALLIC MINERALS.**



## THE MICHIGAN COPPER INDUSTRY IN 1913.

BY REGINALD E. HORE.

Michigan made a poor record in copper mining in 1913. During the first half of the year production was fairly good; but after June 23, the production was small and the cost high. In previous years the production was about 220,000,000 pounds per year; but in 1913 it was only about 150,000,000 pounds.

In previous years the Michigan copper mining district, the "Copper Country" as it is often called, was noted as the location of a thriving industry which supported, and supported well, a large population. To mining men of all classes the Michigan copper mines are known to be well managed. The low grade nature of much of the ore calls for exceptional skill and repeated improvements in methods of mining, milling, and smelting.

### PROFITS FROM COPPER MINING IN MICHIGAN.

Fortunately one of the deposits, the Calumet conglomerate, yielded exceptionally rich ore for many years and the profit from mining in the district has consequently been large, the Calumet & Hecla company alone paying to the end of 1913, \$123,250,000 in dividends and investing several millions in other properties. Of the many other companies operating in the district few have been successful. Those which have paid dividends are the Ahmeek, Atlantic, Baltic, Calumet & Hecla, Central, Champion, Cliff, Copper Falls, Franklin, Kearsarge, Minnesota, Mohawk, Osceola, Quincy, Tamarack, Trimountain and Wolverine. Of these several have long since ceased to pay dividends, the mines having been abandoned. Only seven companies were able to pay dividends during each of the five years 1908-1912.

### LOSSES IN COPPER MINING.

While the Calumet & Hecla has paid large dividends in 1912, a very large number of companies have operated at a loss. Omitting the Calumet & Hecla, the profits and losses of all the operating companies about balance. The companies paid in dividends up to the end of 1913 about \$206,000,000; \$123,250,000 is credited to the Calumet & Hecla, leaving a balance of about \$85,750,000 which may be compared with assessments amounting for the same period to \$87,000,000. It is perhaps surprising to some that mining companies should spend such large amounts instead of closing the



unprofitable mines. The reason is simply that the deposits are so low grade that very large sums must be spent to determine whether they can be profitably mined. One or two pounds of copper per ton may make all the difference between profit and loss. One cent per pound rise or fall in the price of copper means profit or loss in some cases. A large body of ore that allows a very small margin of profit when the price of copper is good has a very doubtful value. No one can foretell with certainty what the price of copper will be when the ore has been mined and treated. Those who engage in mining such ore take a chance. They hope that the price of copper will be good, that they will find better ore as the mine openings are extended and that they will be able to cut down the costs of mining. Needless to say there have been many disappointments as well as some realizations.

#### THE COST OF MINING.

While the price of copper necessarily varies and the mine openings disclose ore of varying value there is a more regular change in the costs of mining. The men who have been in charge of Michigan copper mines have been able to record from time to time great improvements. In spite of the fact that much of the ore is now being mined at great depth the actual cost of mining a ton of ore is now much less than it was years ago. In 1913 costs were unusually high owing to the strike. The costs for several preceding years will be found in the accompanying statistical tables showing summary of results obtained by the producing companies and in previous reports. To the credit of the mine managers it should be stated that decrease in cost has not been brought about by decrease in wages, but rather by improving methods and machines. While costs have gone down wages have been increased.

#### WAGES PAID.

Enormous sums have been paid in wages. During 1912 the employees of Michigan copper mining companies received over \$1,000,000 per month. The Calumet & Hecla company alone has paid about \$200,000,000.00 in wages. A complete statement of wages paid is not available but the accompanying statement of wages paid by companies in 1912 will show that the mining industry in this district is a means of livelihood to thousands of people. The list is by no means complete, as large amounts were paid by several companies not therein mentioned, but it contains all the profitable companies and most of the producing ones.

The wages paid to miners and trammers are shown by the following tables prepared by a committee of the Copper Country Commercial Club:

COPPER INDUSTRY.

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SHIFTS WORKED AND EARNINGS OF MINERS AND TRAMMERS AT VARIOUS COPPER COUNTRY MINES, FOR A PERIOD OF SIX MONTHS, JANUARY 1, TO JUNE 30, 1913.

Mine.	Miners.			Trammers.			Miners and trammers.		
	Days.	Amount.	Average wages.	Days.	Amount.	Average wages.	Days.	Amount.	Average wages.
A.....	19,447	\$69,224.78	\$3.56	17,769	\$50,581.02	\$2.85	37,216	\$119,805.80	\$3.22
B.....	13,473	48,533.81	3.60	15,844	43,206.28	2.73	29,317	91,742.09	3.13
C.....	33,367	115,380.62	3.46	29,029	92,001.39	3.17	62,396	207,382.01	3.32
D.....	72,241	264,984.87	3.67	52,790	153,216.35	2.90	125,031	418,201.22	3.35
E.....	1,450	4,639.94	3.20	1,045	2,610.98	2.50	2,495	7,250.92	2.91
F.....	4,767	16,615.39	3.49	4,504	12,181.10	2.70	9,271	28,796.49	3.11
G.....	367	933.53	2.54	169	439.01	2.54	536	1,362.54	2.54
H.....	30,059	94,003.75	3.13	20,099	51,394.70	2.57	50,159	145,398.45	2.90
I.....	106	425.10	3.98	237	582.72	2.46	343	1,007.82	2.93
J.....	873	2,846.42	3.26	238	587.94	2.46	1,112	3,434.36	3.09
K.....	17,104	61,319.73	3.59	20,311	51,645.06	2.54	37,416	112,964.79	3.02
L.....	12,032	36,420.82	3.03	13,403	34,095.94	2.54	25,435	70,516.66	2.77
M.....	11,502	39,520.34	3.44	10,924	27,762.13	2.54	22,427	67,282.47	3.00
N.....	1,692	5,778.81	3.42	665	1,539.23	2.31	2,357	7,318.04	3.10
O.....	6,701	23,798.71	3.55	4,642	14,564.16	3.14	11,344	38,362.87	3.38
P.....	17,417	56,617.22	3.27	14,692	40,614.45	2.76	32,110	99,231.67	3.09
Q.....	886	4,549.13	5.13	1,514	3,818.44	2.52	2,400	8,367.57	3.49
R.....	39,591	115,881.59	2.93	19,337	44,590.55	2.31	58,928	180,462.14	2.72
S.....	52,129	151,623.65	2.91	21,643	49,932.45	2.31	73,772	201,566.10	2.73
T.....	26,298	77,140.80	2.93	11,041	25,617.35	2.32	37,339	102,758.15	2.75
U.....	16,139	44,629.67	2.77	10,558	23,690.84	2.24	26,697	68,320.51	2.56
V.....	6,843	19,890.40	2.91	3,761	8,544.00	2.27	10,604	28,434.40	2.68
W.....	1,150	3,574.00	3.11	1,213	2,507.91	2.06	2,363	6,381.91	2.70
X.....	35,779	108,961.59	3.05	24,653	62,170.25	2.55	60,432	171,751.87	2.84
Y.....	1,796	5,088.55	2.83	618	1,458.90	2.36	2,415	6,547.45	2.71
Z.....	89,508	270,825.03	3.03	30,400	76,211.25	2.51	119,908	347,086.28	2.99
AA.....	14,072	43,869.77	3.12	13,709	32,984.05	2.38	27,782	76,563.82	2.76
BB.....	15,064	46,688.05	3.10	14,391	35,169.00	2.49	29,456	82,457.05	2.80
Total.....	541,860	\$1,735,786.07	\$3.20	359,210	\$944,909.38	\$2.63	901,070	\$2,680,695.45	\$2.98

PERCENTAGE OF TOTAL SHIFTS WORKED BY MINERS AT VARIOUS RATES, CALUMET AND HECLA AND SUBSIDIARY COMPANIES—MONTH OF MAY, 1913.

Mine.	\$5.00 and over.	\$4.75 to \$4.99.	\$4.50 to \$4.74.	\$4.25 to \$4.49.	\$4.00 to \$4.24.	\$3.75 to \$3.99.	\$3.50 to \$3.74.	\$3.25 to \$3.49.	\$3.00 to \$3.24.	\$2.75 to \$2.99.	\$2.50 to \$2.74.	Under \$2.50.	Total per cent.	Average wages.
Alhneek.....	4.95	6.49	2.08	7.54	7.54	7.54	8.79	22.95	18.33	2.60	8.42	2.77	100.00	\$3.64
Allouez.....	8.61	2.15		6.33	6.33	6.33	6.37	71.99	4.15	0.40			100.00	3.57
Calumet and Hecla.....	0.72	0.53	1.86	3.73	6.31	12.20	14.71	45.26	8.23	5.92	0.53		100.00	3.54
Centennial.....					7.03	10.04		82.93					100.00	3.40
Isle Royale.....			0.99	0.99	3.14	3.93	0.99	40.63	4.90	44.05		0.38	100.00	3.15
North Kearsarge.....	8.52	0.97	1.82	9.64	5.87	0.77	14.66	0.69	57.06				100.00	3.69
South Kearsarge.....				4.94	4.94		13.96	10.38	65.78				100.00	3.06
Oscoda.....	3.03	5.95		5.58	5.70	2.79	49.88	20.82	2.97	3.28			100.00	3.45
Superior.....	8.33	3.84	3.90	4.45	1.07	0.41	3.53	69.77	0.74	3.96			100.00	3.64
Tamarack.....	5.15		5.37	1.77	1.91	6.51	5.88	13.09	45.57	14.75			100.00	3.39
Total percentage..	2.54	1.39	1.76	3.62	4.85	8.02	9.75	39.30	14.33	12.84	1.29	0.31	100.00	\$3.47

PERCENTAGE OF TOTAL SHIFTS WORKED BY TRAMMERS AT VARIOUS RATES, CALUMET AND HECLA AND SUBSIDIARY COMPANIES—MONTH OF MAY, 1913.

Mine.	\$5.00 and over.	\$4.75 to \$4.99.	\$4.50 to \$4.74.	\$4.25 to \$4.49.	\$4.00 to \$4.24.	\$3.75 to \$3.99.	\$3.50 to \$3.74.	\$3.25 to \$3.49.	\$3.00 to \$3.24.	\$2.75 to \$2.99.	\$2.50 to \$2.74.	Under \$2.50.	Total per cent.	Average wages.
Alhneek.....	2.90	0.09		0.83	0.06	1.60	11.19	8.36	12.21	2.56	59.98	0.22	100.00	\$2.93
Allouez.....					1.45	2.60	5.96	4.23	6.58	79.09			100.00	2.68
Calumet and Hecla.....			0.01	0.66	2.15	6.81	13.24	11.78	11.24	6.24	41.56	6.31	100.00	3.08
Centennial.....							2.63	18.79	6.80	71.78			100.00	2.76
Isle Royale.....									4.80	95.20			100.00	2.55
North Kearsarge.....										100.00			100.00	2.54
South Kearsarge.....										100.00			100.00	2.54
Oscoda.....										100.00			100.00	2.54
Superior.....						2.75	9.26	28.33	30.65	25.17	3.03	0.81	100.00	3.17
Tamarack.....									100.00				100.00	2.81
Total percentage..	0.27	0.01	0.00	0.33	0.84	2.96	6.63	6.80	6.64	10.05	62.99	2.48	100.00	\$2.83

\$4.00 and over 14.16%  
 \$3.00 to \$3.99. 71.40%  
 \$2.50 to \$2.99. 14.13%  
 Under \$2.50... .31%  
 Total.....100.00%

\$4.00 and over 1.45%  
 \$3.00 to \$3.99. 23.03%  
 \$2.50 to \$2.99. 73.04%  
 Under \$2.50... .2.46%  
 Total.....100.00%

Compared with wages paid in some mining districts the wages are low. It should be borne in mind however that the Michigan miners enjoy many material advantages which such tables take no account of. The companies provide houses at very low rentals and in many ways relieve the employes of expenditures. Splendid schools, hospitals, libraries, etc., are at the disposal of employees at very low cost.

It will be noted from the tables that there is great variation in the earnings of miners. Some receive very good wages, but the general average is low. The wage paid varies at the different mines, being highest at the Calumet & Hecla. At each mine there is a variation which is fairly indicative of the relative amounts of work done by the individual miners. According to the mine managers the miners who receive the highest wages are the most profitable to the companies. It will be seen from the tables that a number of miners earn over \$4 per day. Most of these men use the light-weight one-man machines, to which the anti-labor-saving device agitators object.

#### EXPLORATION IN 1913.

In the early part of 1913 exploratory work was being carried on by a number of companies besides the producing ones. Diamond drilling was done at the Adventure, Algomah, Keweenaw, Mayflower, Naumkeag, Old Colony and Onondaga.

Exploratory openings were made at the Cliff, Indiana, Keweenaw, Naumkeag, New Arcadian, New Baltic and North Lake.

Development of lodes was continued at the Hancock, Houghton, Laurium, Lake, Ojibway, St. Louis, White Pine and Wyandot.

During the strike many of these companies continued their work without interruption. The diamond drilling was not stopped by the strikers. The White Pine continued operations; but most of the companies doing any underground work were forced to close down their mines and wait for more peaceful and less costly conditions for operation.

#### NEW CONSTRUCTION.

During 1913 there were several important additions made to the already extensive equipment of the mining companies.

The Calumet & Hecla company made a number of additions to plants, including some very notable ones. At the power house an enormous electric turbine generator has been erected to utilize the exhaust steam from the stamps. At the smelter the two large furnaces which were under construction in 1912 were completed and an electrolytic plant of large capacity was erected. This plant is a splendid one and has very few equals in the world. When it is in operation the Calumet & Hecla company will be able to ship all of its copper in

the refined state. At present much of the copper is ready for the market when it leaves the smelter, but some is sent to the company's plant at Buffalo for electrolytic treatment. At the mill a large building has been erected to house a regrinding plant which is to be equipped with 64 Hardinge conical mills. At the end of the year some of the mills were in position and the plant will doubtless be in operation before the end of 1914. Experiments have been carried on to determine the advisability of leaching the tailings from the regrinding plant. It is stated that a successful process has been devised and that a large plant will be built.

The Copper Range Consolidated company has made many improvements at its mills. Regrinding apparatus has been erected and turbines have been installed to develop the increased power necessary. At the mines the underground electrical equipment was extended and several motors are now in use to haul the ore to the shafts.

The Quincy Mining company installed a new hydraulic jig classifier devised by the company's staff and consulting metallurgists. The new apparatus, known as the Shields-Thielman jig classifier is giving great satisfaction.

At several of the mines new rockhouses were built and old ones improved. At the mills, especially those of the Calumet & Hecla subsidiary companies, there were many additions and improvements. At the Winona mill a new device known as the Lovett machine was found very successful in treating fine copper. It rolls the copper and makes its concentration easier.

During the year a company interested in power development did some preliminary work with the view to supplying the mines with power from the Sturgeon river.

#### EARNINGS 1913.

The first half of the year was a profitable one for several companies, but the last half was disastrous. In spite of the strike a few companies are able to report a profit on the years' operations. The statistical tables on another page show concisely the result of the year's business for the more active companies.

#### DIVIDENDS PAID IN 1913.

While the mines were idle for several weeks and short handed for some months the leading companies were able to pay out more than was earned during the year and consequently the amount paid was little less than in the previous year. Assets have however been considerably reduced.

## ADVENTURE CONSOLIDATED COPPER CO.

Early in 1913 all work was discontinued at this company's property pending the result of operations on adjoining properties.

## AHMEEK MINING COMPANY.

Until the strike occurred the Ahmeek was making a large production and promised to have a very successful year. The main ore deposit, the Kearsarge lode, yielded good ore and the fissure vein north of No. 2 shaft proved very rich. The vein has been opened up for 419 feet on the 10th level, 70 feet on the 13th level, and 212 feet on the 14th level.

Owing to the satisfactory condition of the mine and of the treasury, the company was able to pay \$850,000 in dividends; but the balance of assets was reduced from \$1,379,209.34 to \$706,128.53.

There was treated in 1913, 383,749 tons of ore yielding 9,220,184 pounds copper, an average of 24.0 pounds per ton.

Mr. R. L. Agassiz, President, says in his annual report that new openings at No. 1 and No. 2 shafts showed average values except at the 17th level. Comparatively little opening was done at Nos. 3 and 4 shafts on account of construction.

At the mill a four-stamp addition is in course of construction. A contract has been let for a 2,000 kilowatt low pressure steam-turbine, which will be supplied with steam from the exhaust of the steam stamps and will furnish all the necessary power for operating the washing and recrushing machinery in the mill.

## ALGOMAH MINING COMPANY.

During the first half of the year the shaft was sunk 203 ft. and the crosscut at the second level was extended northwest 228 feet. No mining work was carried on after July 23. The president states that when work is resumed the shaft will be deepened.

## ALLOUEZ MINING COMPANY.

The Allouez was making good progress before the strike and made a profit of \$155,728.21 on the year's operations. Openings were quite up to the average and a good profit from future operations is assured. The Allouez produced during the year 4,091,129 pounds of copper from 236,663 tons of ore treated, an average of 17.29 pounds per ton.

## BALTIC MINING COMPANY.

The Baltic was making good progress when the strike interfered with

operations. The mill was improved by the addition of regrinding apparatus and is giving very satisfactory results

The Baltic produced in 1913, 7,736,124 pounds copper at a cost of 11.91 cents per pound. This was sold at 14.89 cents. Mr. F. W. Denton, General Manager, reports that openings at No. 2 and No. 3 shaft were good, while the openings at No. 4 were in poor ground. He anticipates rapid recovery to normal conditions.

#### CALUMET & HECLA MINING COMPANY.

The Calumet & Hecla, the largest of the Michigan copper mines, was operated very profitably until July 23. After being idle a few weeks the mine was reopened and at the close of the year there were as many men at work as before the strike. The company bore a large share of the expense of the strike.

The company made important additions to plant during the year. A second regrinding plant is well advanced and an electrolytic refinery is nearly ready for operation.

In the regrinding plant there will be 64 Hardinge Conical mills. The concentration will be done on Wilfley tables. With this plant in operation the company will begin to recover the copper contained in the stamp mill tailings which have been accumulating for years.

The refinery will have a capacity of 65,000,000 pounds deposited copper per year. This plant will therefore be able to handle all of the company's product, as only a portion of the copper needs to be subjected to electrolytic treatment for the recovery of silver or the removal of harmful impurities.

The two large furnaces which were under construction in 1912 have been completed. Most of the copper treated in these will be cast into anodes.

At the power house a 7,500 kilowatt electric turbine generator which was being installed in 1912 is now in operation.

To raise the sands from Torch lake the company has had built an enormous steel dredge. Centrifugal pumps will raise the sand to settling boxes in a Shore plant. After draining, the sand will be hoisted on a traveling belt and crushed in the Hardinge mills referred to above.

During 1913 there was treated 2,035,625 tons of ore, which yielded 45,016,892 pounds of copper, an average of 22.11 pounds per ton. The total cost per pound was 14.25 cents and the price received for copper sold was 15.77 cents.

As usual the chief production was from the Conglomerate lode. This yielded 32,731,768 pounds copper at a cost of 12.67 cents. The

Osceola lode yielded 12,051,238 pounds and the Kearsarge lode 233,915 pounds.

At the Manitou-Frontenac Branch three diamond drill holes were made. At the St. Louis branch the shaft was deepened and 1,237 feet of drifting was done.

The company estimates that the new regrinding plant, working at its capacity of about 3,000 tons per day, would retreat the available sands in Torch Lake in about 30 years and save five pounds of copper per ton at a cost of about six cents, giving a profit if sold at thirteen and one-half cents per pound of over \$10,000,000 less the cost of the mill and power equipment. An equal profit is expected from further treatment of the sands by leaching.

The Calumet & Hecla paid \$3,200,000 in dividends in 1913 and received from other mining companies in dividends, \$915,439. Dividends received exceeded interest paid on notes by \$716,379.

#### CENTENNIAL COPPER MINING COMPANY.

The Centennial did very well during 1913, considering the conditions, and made a profit of \$31,397.00. There was treated during the year 85,443 tons of ore, which yielded 1,612,262 pounds copper, an average of 18.87 pounds per ton. The total cost was 13.38 cents and the price received for copper sold was 15.358 cents per pound.

No work was done at No. 1 shaft. The openings north of No. 2 shaft were according to Mr. Quincy A. Shaw, President, up to the average.

The balance of assets on December 31, 1913, was \$27,847.78.

#### CLIFF MINING COMPANY.

The exploration carried on from the temporary shaft proved unsatisfactory and was discontinued early in June. Since then the company has bored three diamond drill holes in the eastern part of the property.

#### CONTACT COPPER COMPANY.

Four diamond drill holes constitute the exploration done in 1913. All work was discontinued on August 2.

#### COPPER RANGE CONSOLIDATED COMPANY.

The company from the Baltic, Trimountain and one-half Champion produced in 1913, 18,767,359 pounds copper at an average cost of 11.71 cents. This was sold at 14.89 cents per pound.

Profits from the individual mines were: Baltic, \$230,211.37; Trimountain, \$113,363.24; Champion, one-half, \$252,383.30.



Mr. W. A. Paine, President, reports that extraordinary expenses, mostly in connection with the regrinding installation, amounted to \$230,835.97. Until the strike, operations had shown an improvement over the previous year. He states that the mines are in good condition and satisfactory results may be expected in 1914.

#### FRANKLIN MINING COMPANY.

The Franklin had a very unsatisfactory year owing to labor conditions. There was a shortage of trammers early in the year. After July 23 no mining was done.

Early in 1914 the Allouez conglomerate, which lies east of the Pewabic lode, was opened up at the 32nd level. The company reports that samples of four and one-half and eight tons representing 15 feet of the lode were assayed and found to contain 31.8 and 35.2 pounds copper per ton. This lode will now be developed.

The Franklin produced in 1913, 123,179 tons of ore which yielded 1,021,440 pounds of copper. There was a much larger tonnage of ore broken but lack of trammers prevented its being hoisted.

Receipts during 1913 amounted to \$164,556.45, while expenses totalled \$306,660.59. The deficit at the end of the year was \$100,264.87.

#### HANCOCK CONSOLIDATED MINING CO.

The company continued exploration of the deposits cut by No. 2 shaft by crosscuts and drifts; 12,612 tons of ore from drifting on the several lodes and from stopes on No. 3 and No. 9 lodes was stamped and yielded 16.82 pounds copper per ton. After July 23 operations were suspended for the balance of the year.

Mr. J. L. Harris, General Manager, says, in his report for the year 1913 that development work on No. 9 lode at the 13th and 18th levels has been satisfactory, the ore mined being of good grade.

#### HOUGHTON COPPER COMPANY.

The company continued exploration by drifts at the 620 feet and 820 feet levels, and by a winze. After July 23 operations were suspended.

Mr. R. R. Seeber, superintendent, says in his report for the year 1913, that the north drift on the 820 foot level showed copper most of the way, while the south drift was in average ground.

#### INDIANA MINING COMPANY.

The company deepened its shaft to the level at which it was expected to find a deposit cut by diamond drill holes. The cores showed

copper in felsite at a point believed to be close to the bottom of the shaft. The completion of the shaft showed, however, that the drill hole survey was incorrect as the shaft is bottomed in trap. As very considerable deviations are common in drill holes, it is thought that the deposit can be best developed by following the deposit exposed at the 600 foot level which is similar to that cut by the diamond drill.

No work was done at the property after July 23.

#### ISLE ROYALE COPPER COMPANY.

The Isle Royale had a serious set back in 1913, owing chiefly to the strike; but partly also to a decrease in the yield of copper per ton of ore stamped. There was a decrease of \$382,301.91 in balance of assets as a result of the year's operation; \$100,000 of this was due however to purchase of land and \$150,000 to dividend. The loss properly attributed to operation, including strike expenses, was \$128,313.04.

During the first six months good progress was made in opening up the mine for larger production. The openings made totalled 11,972 feet. Development work after July 23 was necessarily curtailed. The yield of copper per ton of ore was disappointing, being 13.2 pounds. The average yield in 1912 was 15.4.

The Isle Royale produced in 1913, 314,679 tons of ore which yielded 4,158,548 pounds copper. This cost 18.81 cents per pound.

Mr. R. L. Agassiz, President, reports that openings at No. 4 and No. 5 shafts were in average ground, while those at No. 2 and No. 6 were below average.

#### LAURIUM MINING COMPANY.

Development work at the No. 1 shaft was carried on without notable results; \$26,486 was expended and the company ended the year with a balance of liabilities of \$8,020.

#### LAKE COPPER COMPANY.

The Lake mine was operated under adverse conditions early in the year, and was closed by the strike. Later it was operated again; but again closed on account of the unusual high cost.

Mr. C. H. Hitchcock, the mine superintendent resigned and Mr. E. W. Walker, superintendent of the Mass mine, was appointed to take charge of the Lake mine also.

## KEWEENAW COPPER COMPANY.

Diamond drilling was done during 1913 to explore the Ashbed lode east and west of Lake Medora. Fourteen holes giving a total of 7,911.5 feet were drilled. It is intended to continue this work.

On the property of the Phoenix Consolidated Company exploration was also carried on. See Phoenix.

## LASALLE COPPER COMPANY.

Work was resumed at the property during 1913; but little had been done when the strike interfered with progress. The company's balance of assets was reduced to \$158,827. There was treated during the year 2,221 tons of ore yielding 43,906 pounds of copper.

## LAKE MILLING, SMELTING AND REFINING COMPANY.

A number of improvements were made in plant during the year and more will be made in 1914. Regrinding apparatus is being provided and new concentration machinery is being installed.

## MASS CONSOLIDATED MINING COMPANY.

The mine has been put in very good shape for production and with satisfactory labor conditions would have given a good account of itself. The superintendent found however that under the conditions existing in 1913 it was better for the company to close the mine.

The Mass produced in 1913, 1,213,545 pounds copper which was sold at 15.6 cents.

## MAYFLOWER MINING COMPANY.

Exploration was carried on during 1913 without interruption.

Mr. Charles J. Paine, Jr., President, reports that the drilling operations have materially increased the area which is demonstrated as being underlain by the Mayflower lode. In a number of places the lode has been found to be more or less displaced by faulting.

## MICHIGAN MINING COMPANY.

The company has been doing no mining for some years. After operating for several years the company for some time carried on exploratory work. Some mining was done by tributors. During 1912 a shaft was started to explore the Ogima lode.

All operations have now been suspended.

## MOHAWK MINING COMPANY.

The company suffered seriously from labor troubles during 1913. Early in the year the trammers went on strike. This lasted only a few days. After July 23 the mine was closed for some time. When it was opened again the small size of the working force resulted necessarily in high costs; \$500,000 was paid in dividends but the surplus was reduced from \$897,316 to \$521,156.

The Mohawk produced in 1913, 366,458 tons of ore which yielded 5,778,235 pounds copper. This cost 13.22 cents per pound.

## NAUMKEAG COPPER COMPANY.

The company has 1200 acres in the western part of the copper bearing formation. This is being explored by drilling, trenching and small underground openings. Eleven holes have been drilled, totalling 13,913 feet. Work is now being confined to the Quincy-Pewabic horizon.

## NEW ARCADIAN COPPER COMPANY.

Exploration was continued during nine months of the year. From August 1 to November 1, the work was suspended on account of the strike.

A crosscut east at the 750 foot level disclosed a promising copper bearing amygdaloid. This was drifted on with good results. Mr. H. W. Fesing, the company's engineer, reports that of 200 feet of drifting on this deposit all but 25 feet shows good ore.

## NEW BALTIC COPPER COMPANY.

Exploration was carried on during the first half of the year, but after July 23 no underground work was done. Mr. H. W. Fesing, engineer, says in his annual report that the most important development during the past year, as affecting the New Baltic property, is the opening up of the amygdaloid lode on the New Arcadian property close to the boundary line of the New Baltic.

The treasurer's report shows a balance on hand on January 1, 1914, of \$23,956.13.

## NONESUCH MINE.

During the year some work was done at the company's property in Ontonagon county. After the mine had been unwatered and examined, however, the work was discontinued.

## NORTH LAKE MINING COMPANY.

Exploratory work was carried on until July 23, after which date all work was suspended. Mr. R. M. Edwards, President, says in his annual report that all plant and equipment necessary for the development of the property is completed. The shaft was sunk 282 feet during the year and the total depth is now 345 feet. At the 300 foot level a crosscut was driven northwest 112 feet.

The treasurer's report shows a balance of assets on December 31, 1913, of \$49,408.33, including unpaid assessments of \$31,724.

## OJIBWAY MINING COMPANY.

The Ojibway mine was operated early in the year without very encouraging results. It is now closed down.

## OLD COLONY COPPER COMPANY.

Exploration was continued during 1913 by diamond drilling. In a report dated December 10, 1913, Mr. H. H. Fay, President, says that 9 holes totalling 12,627 feet were drilled during the year and that the horizon of the Mayflower lode was definitely located in every drill hole.

## ONECO COPPER COMPANY.

Exploration was continued by cross cuts and drifts until the strike occurred on July 23. After that date no work was done.

## ONONDAGA COPPER COMPANY.

During 1913 exploration was carried on by diamond drilling on the company's lands in Ontonagon county. Mr. W. B. Smith, Superintendent, resigned and Mr. H. W. Fesing is now in charge of operations.

Mr. R. C. Pryor, President, in a report to stockholders says that diamond drilling has been carried on continuously since August, 1912. A geological and topographical survey of the company's lands has been made.

The treasurer's report shows a balance of \$74,675 on hand on January 31, 1914.

## OSCEOLA CONSOLIDATED MINING COMPANY.

In spite of the very adverse conditions the company made a profit of \$381,967 and paid dividends of \$721,125.

The report of the directors shows that there was stamped 735,044

tons of ore. The production of refined copper was 11,325,010 pounds or 15.4 pounds per ton. The cost was 12.30 cents per pound and 10,958,926 pounds was sold at 15.50 cents.

At the Osceola branch the cost per pound was 20.79 cents, at the North Kearsarge 12.46 cents, and at the South Kearsarge 8.11 cents. Of the 256,233 tons mined at the South Kearsarge branch, nearly two-thirds was mined from the footwall.

As a result of the small earnings and large distribution in dividends the balance of assets was reduced from \$1,888,458.05 to \$1,549,300.06.

#### PHOENIX CONSOLIDATED COPPER COMPANY.

After obtaining encouraging results by diamond drilling the company opened up an old shaft in the Ashbed lode. This old shaft has been unwatered and enlarged. In the work of enlarging the shaft some good ore was broken and the company intends to deepen the shaft below the old workings. In his report, Mr. T. F. Cole, President, says that an examination of the openings made on and above the first level of the old workings shows good copper values.

#### QUINCY MINING COMPANY.

This company which has been successfully mining low grade ore for many years made a profit of only \$76,160 in 1913 as compared with \$960,779 in 1912. There was produced 12,184,128 pounds of copper at a cost of about 15.3 cents per pound. This was sold at 15.59 cents.

During the year \$412,500 was paid in dividends and \$150,000 was paid on note given St. Mary's Canal Mineral Land Co. The balance of assets was decreased from \$1,233,278.15 to \$746,938.34.

Mr. Chas. L. Lawton, General Manager, reports that a new 90 pound drilling machine has been successfully tried out in the mine, and that the company has ordered 100 machines of this type. He says that there has been no particular change during the year in the average copper contents of the ore developed at No. 2 shaft, though the openings as a whole are looking better for stamp rock and heavy copper than years ago. He says that at the No. 6 shaft the bottom openings average about the same in stamp copper as for several years, but do not carry the old quantity of heavy copper. At the No. 8 shaft the average of the openings is below that of other years, but the bottom levels look well.

#### ST. LOUIS COPPER COMPANY.

Exploration was continued during 1913 by extending the workings at No. 1 shaft. The shaft was deepened and drifting along the lode

continued. Copper was found in places; but no large body of good ore has yet been found.

#### SOUTH LAKE MINING COMPANY.

Development was carried on by shaft sinking and cross-cutting until July 23. After that date no work was done, pending improvement in labor conditions. Mr. R. M. Edwards, General Manager, in his annual report says that the shaft has been sunk to a depth of 537 feet and a crosscut driven at the 300 feet level to open the lodes known as Nos. 1, 2 and 3 cut in the shaft between depths of 110 and 210 feet.

At 600 feet a long crosscut will be driven southeast to cut the lodes found by diamond drilling.

The treasurer's report shows a balance of assets on January 1, 1914, of \$46,606.36.

#### SUPERIOR COPPER COMPANY.

The Superior had a fairly successful year, being one of the first to resume large shipments after the strike began. Before the strike attention was devoted chiefly to developing the lodes. This was proceeding with fair results when the strike was called.

The company produced 2,992,765 pounds of copper, the ore stamped averaging 22.87 pounds copper per ton. A profit of \$93,912.93 was made, increasing the balance of assets to \$193,697.01.

In his annual report Mr. Quincy A. Shaw, President, says that no copper was developed in the Superior lode south of the shaft and that the ground opened on the 16th and 17th levels north of the shaft is below average. Good ore was opened south of No. 1 shaft on the 17th, 18th, 19th and 20th levels in the West lode; but development north failed to show anything of value except on the 20th level near the shaft.

#### TAMARACK MINING COMPANY.

The Tamarack mine has for the past few years been a high cost mine. In several recent years it was operated at a loss. During 1912 a profit was made. With plenty of good men available 1913 would also have been a profitable year. After the strike the mine was closed for the balance of the year pending improvement in the labor situation.

During 1913 there was produced 4,168,743 pounds of copper at a cost of 16.60 cents per pound; 3,852,040 pounds was sold at 15.45 cents. Considering the conditions the loss from operations was not very large. The balance of assets was decreased from \$1,120,861.88 to \$1,070,938.19.

Openings at No. 3 shaft, according to the report of President R. L. Agassiz, have shown fair copper values. At No. 2 shaft very little drifting was done on the conglomerate lode. A considerable tonnage of ore was mined from the footwall side of the Osceola amygdaloid lode at this shaft.

The Tamarack company has a very large tonnage of mill tailings which is expected to yield a large profit when treated. Concerning this Mr. R. L. Agassiz says: "It has been estimated that a mill of a capacity of 1,500 tons a day will treat the available sands in 21 years, saving about four pounds of copper out of 12.4 pounds in a ton of sand, at a cost of about seven cents, giving a net profit, if sold at thirteen and one-half cents per pound, slightly over \$2,500,000, less the cost of the plant." Experiments that have been carried on at the Calumet & Hecla stamp mills indicate that a leaching process has been developed which, if applied to a portion of the tailings of this recrushing mill, will result in an additional profit from the sands of the same amount, or a total profit of \$5,000,000. The construction of the recrushing mill will not be undertaken until all details have been worked out at the Calumet & Hecla stamp mills.

#### TRIMOUNTAIN MINING COMPANY.

The company had a fairly good year in spite of the strike. The openings made were good and the yield of copper was unusually high. There was produced 4,990,938 pounds copper, the ore yielding 21.78 pounds per ton. The cost was 12.62 and the selling price 14.89 cents per pound.

During the year the installation of improved drilling machines was completed. Three of the four heads at the mill are now equipped with regrinding machinery.

Receipts for the year totalled \$746,529.86. Operating expenses were \$608,922.11. After paying taxes amounting to \$24,244.41 there was a net profit of \$113,363.34. As \$200,000 was paid in dividends the surplus was reduced and amounted on December 31, 1913, to \$444,757.68.

#### VICTORIA COPPER MINING COMPANY.

This company experienced in 1913 one of the best years in its history. The mine being far removed from the centre of strike disturbances, operations were carried on without interference. Early in the year there was a scarcity of men but the closing of mines in Houghton county was an advantage to the Victoria.

A large amount of development work was done and good results were obtained. The year's operations resulted in a decrease of \$16,938 in surplus but the outlook has been greatly bettered.



The production was 1,428,693 pounds copper.

Mr. Geo. Hooper, Superintendent, says in his report for 1913 that the ore developed during the past two years is better than that opened in preceding years. The average yield in 1913 was 2.4 pounds per ton higher than in 1912.

#### WHITE PINE COPPER COMPANY.

The company has been carrying on development work for the past few years with good results, and is now planning to erect a mill and begin production in 1914. During 1913 the openings were extended and a large body of good ore blocked out. The employees did not take part in the strike, and good progress was made.

The ore is quite different to that being mined in other parts of Michigan. It is a sandstone containing copper in small particles.

Mr. Quincy A. Shaw, President, reports that work on the building and machinery for a mill of a capacity of 1,000 tons per day has been started. The mill will be equipped with gyratory crushers, rolls, Woodbury classifiers, Wilfley tables, and Hardinge pebble mills.

#### WINONA COPPER COMPANY.

The company did fairly well during 1913, considering the labor conditions. Early in the year there was a shortage of trammers at the mine. After the strike was called the mine was closed until October. Slowly the force was increased and at the end of the year prospects were good.

There was produced during 1913, 1,448,737 pounds of copper, the ore yielding 11.99 pounds per ton. The annual report shows a balance of assets of \$74,508.16 compared with \$62,034.12 a year ago.; \$128,506 was collected by assessments.

Three Hardinge Conical mills were added to the regrinding plant during the year, and very good results were obtained.

Mr. A. L. Dickerman made a study of the extraction problem at the Winona mill during the year and recommended the use of the Shields & Thielman jig classifier and the Lovett grinding machine.

#### WOLVERINE MINING COMPANY.

The Wolverine's financial year ending June 30, 1913, was a fairly good one; but the last five months of 1913 was a very unprofitable period. It was not until some months after the calling of the strike that any considerable amount of ore was being mined. At the end of the year production was still small.

WYANDOT COPPER COMPANY.

During 1913 the company continued exploration of the No. 8 lode. The mine was closed for one month during the strike. The superintendent, Mr. F. L. Van Orden, recommends further development of the No. 8 lode.



## COPPER INDUSTRY.

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SUMMARY OF FINANCIAL STATEMENTS OF MICHIGAN MINING COMPANIES FOR THE YEAR 1913.

	Balance of assets (+) and liabilities (-) Dec. 31, 1912.	Receipts, 1913.			Expenditures, 1913.			Balance of assets (+) and liabilities (-) Dec. 31, 1913.
		Sale of copper and silver.	Assessments.	Other income.	Mining, milling, smelting, construction, etc.	Interest, taxes, and other expenses.	Dividends.	
Almreek.....	+\$1,379,209 34	\$1,433,695 62	\$70,000 00	.....	\$1,226,275 68	\$30,500 75	\$850,000	+\$706,128 53
Algoma.....	11,840 31	.....	.....	.....	29,730 38	870 00	.....	+27,707 39
Algonac.....	+93,564 21	650,202 58	.....	\$148 58	485,119 37	9,358 00	.....	+249,292 42
Baldwin.....	+308,106 25	1,152,026 59	.....	7,266 49	872,914 91	48,900 31	200,000	+338,317 72
Calumet and Hecla.....	+4,897,414 31	.....	.....	.....	.....	.....	3,200,000	+2,419,964 05
Centennial.....	-3,549 22	246,688 78	.....	431 74	208,243 87	7,479 65	.....	+27,847 78
Champion.....	+943,875 84	1,798,984 15	.....	3,546 19	1,169,072 00	128,691 03	900,000	+548,643 15
Cliff.....	+62,571 79	.....	.....	1,719 39	17,973 69	.....	.....	+48,317 52
Franklin.....	+41,830 27	156,807 26	.....	7,749 19	261,031 17	45,628 42	.....	+100,264 47
Gratiot.....	-358,510 27	.....	.....	.....	.....	.....	.....	-379,852 73
Hancock.....	-124,288 66	33,912 88	13,280 00	\$165,000 00	193,156 07	13,247 08	.....	-291,234 45
Houghton.....	-3,353 46	.....	.....	.....	.....	.....	.....	-15,265 23
Indiana.....	+53,080 23	.....	.....	538 29	46,868 47	.....	.....	+8,730 05
Isle Royale.....	+557,743 48	649,946 08	.....	.....	778,259 12	\$103,988 87	150,000	+175,441 57
LaSalle.....	+240,659 65	6,585 57	.....	8,949 99	97,368 17	.....	.....	+158,827 04
Laurium.....	+18,465 42	.....	.....	.....	26,463 43	22 93	.....	-8,020 94
Mass.....	+19,347 76	180,325 95	.....	231 39	206,708 05	10,857 99	.....	-18,658 94
Mayflower.....	+55,646 52	.....	475 00	1,832 69	36,449 63	6,839 70	.....	+14,684 88
Mohawk.....	+897,316 40	887,618 50	.....	.....	712,038 21	24,088 90	500,000	+521,155 92
Naumkeag.....	+253,000 00	.....	.....	.....	.....	.....	.....	211,989 00
New Arcadian.....	+624 76	.....	63,081 50	11,813 16	23,015 76	4,745 44	.....	+24,558 22
New Baltic.....	+23,576 73	.....	.....	379 40	18,828 16	1,219 70	.....	+3,908 27
North Lake.....	-13,835 30	.....	100,000 00	956 74	37,109 32	603 79	.....	+49,408 33
Onondaga.....	+102,115 85	.....	.....	.....	.....	.....	.....	+74,675 16
Osceola.....	+1,888,468 05	1,753,626 39	.....	21,184 22	1,392,843 60	.....	721,125	+1,549,300 06

## MINERAL RESOURCES OF MICHIGAN.

SUMMARY OF FINANCIAL STATEMENTS OF MICHIGAN MINING COMPANIES FOR THE YEAR 1913.—Con.

	Balance of assets (+), (-) liabilities, Dec. 31, 1912.	Receipts, 1913.			Expenditures, 1913.			Balance of assets (+), (-) liabilities, Dec. 31, 1913.
		Sale of copper and silver.	Assessments.	Other income.	Mining, milling, smelting, con- struction, etc.	Interest, taxes, and other expenses.	Dividends.	
Quincy.....	+ \$1,233,278 15	\$1,921,198 63	.....	\$18,928 18	\$1,756,178 23	\$79,654 84	\$412,500	+ \$746,938 34
Seneca.....	- 142,318 90	.....	.....	.....	.....	.....	.....	- 154,454 75
South Lake.....	+29,885 77	.....	.....	67,177 40	46,680 17	3,776 64	.....	+46,806 36
Superior.....	+99,784 08	478,977 35	.....	.....	380,788 33	4,276 09	.....	+193,697 01
Tamarack.....	+1,120,861 68	642,713 10	.....	853 54	691,940 13	1,550 00	.....	+1,070,938 19
Trimountain.....	+531,394 34	743,226 51	.....	3,303 35	608,922 11	24,244 41	200,000	+444,757 68
Victoria.....	+27,623 58	215,904 91	.....	12,340 79	236,529 32	8,744 45	.....	+10,885 51
White Pine.....	-16,701 36	.....	.....	88,701 66	84,056 52	7,975 00	.....	+4,080 32
Winona.....	+62,034 12	223,299 20	\$128,506 00	5,396 26	331,304 52	13,422 90	.....	+74,508 16
Wolverine.....	+746,520 15	1,326,500 81	.....	.....	685,115 58	30,871 18	to 600,000	+748,034 20
Wyandot.....	+53,704 48	.....	80 00	531 59	27,428 39	.....	.....	+28,887 68
Total.....	+ \$15,055,284 83	\$14,511,333 54	\$375,422 50	\$428,993 23	\$12,688,710 33	\$620,556 07	\$7,733,625	+ \$9,554,278 08

## Assets, +

<sup>1</sup> Ahmeek paid \$30,500.75 for land purchased.

<sup>2</sup> Hancock borrowed \$165,000 during 1913.

<sup>3</sup> Wolverine report is for year ending June 30, 1913.

<sup>4</sup> Houghton county taxes.

<sup>5</sup> Isle Royale paid \$25,000 cash and gave note for \$75,000 on account of Montezuma lands.

<sup>6</sup> Calumet and Hecla, surplus of cash and quick assets December 31, 1913, \$6,553,964.05; notes outstanding dated February 18, 1909, \$4,134,000.

<sup>7</sup> Quincy paid \$150,000 on note given St. Mary's Land Co., due July 1, 1913 and \$27,834.64 on account of accidents.

<sup>8</sup> Mohawk paid \$27,652.87 strike expenses.

<sup>9</sup> New Arcadian paid loans amounting to \$23,200.

<sup>10</sup> Wolverine paid \$300,000 dividends in 1913, and total of \$600,000 for fiscal year ending June 30, 1914.

<sup>11</sup> Ahmeek dividend of \$350,000 declared December, 1912, paid January, 1913, and \$100,000 declared 1913, paid in January, 1914. Actually paid out \$1,100,000 in 1913 but had charged \$350,000 against 1912 and \$100,000 against 1913.

## COPPER INDUSTRY.

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## DIVIDENDS PAID BY MICHIGAN COPPER COMPANIES.

Name.	1908.	1909.	1910.	1911.	1912.	1913.	All years.
Almreek.....				\$100,000	\$900,000	\$1,100,000	\$2,100,000
Atlantic.....				500,000	700,000	200,000	990,000
Baltic.....	\$990,000	\$1,000,000	\$1,000,000	2,400,000	4,200,000	3,200,000	7,950,000
Cadumet and Hecla.....	2,000,000	2,700,000	2,800,000				123,250,000
Central.....							2,130,000
Champion.....							
Cliff.....	500,000	500,000	900,000	500,000	1,100,000	900,000	8,400,000
Copper Falls.....							2,518,620
Franklin.....							100,000
Isle Royale.....						150,000	1,240,000
Keararge.....							150,000
Minnesota.....							180,000
Molawak.....	250,000	300,000	200,000	150,000	350,000	500,000	1,820,000
Oscoda.....	192,300	769,200	591,500	721,125	1,201,875	1,009,575	3,150,000
Quincy.....	495,000	440,000	412,500	440,000	550,000	412,500	11,891,225
Ridge Copper Co.....							20,842,500
Tamarack.....							100,000
Trimountain.....	500,000		150,000		300,000	200,000	9,420,000
Wolverine.....	600,000	600,000	600,000	540,000	600,000	500,000	7,450,000
							7,740,000
Total.....	\$5,527,300	\$6,309,200	\$7,124,000	\$5,351,125	\$9,901,875	\$7,972,074	\$205,402,345

<sup>1</sup> \$350,000 dividend declared in December, 1912, paid in January, 1913.

<sup>2</sup> Oscoda dividend of \$288,450 paid in January, 1913, was declared December, 1912 and credited to 1912 dividends, 1913 dividends actually amount to \$721,125.

<sup>3</sup> Wolverine fiscal year ends June 30, 1913.

## MINERAL RESOURCES OF MICHIGAN.

## PRODUCTION OF MICHIGAN COPPER MINES IN RECENT YEARS.

(Pounds Avoidedpols.)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	
Almoeck.....	5,510,985	6,280,241	9,198,113	11,844,954	15,196,127	16,455,769	9,220,874	Almoeck.
Allouez.....	2,934,116	3,047,051	4,031,632	4,653,702	4,780,494	5,525,455	4,091,129	Allouez.
Baltic.....	16,704,868	17,724,854	17,817,836	17,549,762	15,370,449	13,373,961	7,636,124	Baltic.
Calumet and Hecla.....	83,863,116	82,549,979	80,096,995	72,059,545	74,130,977	67,856,429	45,016,890	C. and H.
Centennial.....	2,373,572	2,196,377	2,583,793	1,572,566	1,493,834	2,567,365	1,612,262	Centennial.
Champion.....	16,489,436	17,786,763	18,005,071	19,224,174	15,639,426	17,225,508	12,084,594	Champion.
Franklin.....	4,401,248	3,707,513	5,615,556	966,353	820,203	1,710,651	1,021,440	Franklin.
Isle Royale.....	2,667,608	3,011,664	5,719,056	7,567,339	7,490,120	8,186,957	4,158,548	Isle Royale.
Keweenaw.....	.....	122,474	57,091	36,682	633,778	.....	.....	Keweenaw.
LaSalle.....	.....	.....	.....	318,050	280,598	.....	287,200	LaSalle.
Lake.....	2,078,677	1,766,930	1,723,436	1,321,885	1,326,898	2,045,006	1,713,545	Lake.
Mase.....	2,665,404	3,000,206	1,979,305	.....	327,773	162,950	.....	Mase.
Michigan.....	10,107,266	10,295,881	11,248,474	11,412,066	12,091,056	11,993,598	5,778,235	Michigan.
Mohawk.....	.....	.....	.....	.....	.....	.....	.....	Mohawk.
Oscoda.....	14,134,753	21,250,794	25,296,657	19,346,566	18,388,193	18,413,387	11,325,010	Oscoda.
Quincy.....	19,796,058	20,600,361	22,511,984	22,517,014	22,252,943	20,634,800	12,184,128	Quincy.
Superior.....	.....	21,244	1,781,315	3,181,041	3,236,233	3,921,974	2,992,765	Superior.
Tamarack.....	11,078,604	12,806,127	13,533,207	11,063,606	7,494,077	7,908,174	4,168,743	Tamarack.
Trimountain.....	8,190,711	6,034,908	5,282,404	5,694,868	6,120,417	6,903,713	4,990,938	Trimountain.
Victoria.....	1,207,237	1,280,040	1,062,218	1,164,564	1,303,331	1,224,911	1,428,693	Victoria.
Winona.....	1,285,863	.....	.....	.....	1,275,675	2,307,237	1,448,737	Winona.
Wolverine.....	9,272,351	9,955,233	9,971,482	9,666,534	9,630,639	9,120,485	10,782,405	Wolverine.
Totals (U. S. G. S. figures. including products of some other mines.)	219,131,503	222,289,584	227,005,923	221,462,984	219,840,201	231,112,228	155,715,286	
(Smelter returns).....	.....	.....	.....	.....	.....	.....	.....	
Value copper.....	\$43,553,446	\$29,473,944	\$30,437,749	\$28,280,800	\$27,480,013	\$35,992,837	\$21,037,278	
Value silver.....	197,844	127,759	148,944	179,470	263,559	324,999	178,285	
Total value.....	\$43,751,290	\$29,601,603	\$30,586,693	\$28,459,270	\$27,743,572	\$36,317,836	\$21,235,563	

Most of these figures are from reports of the mining companies. The remainder are the best obtainable from other sources.

WORLD'S PRODUCTION OF COPPER.<sup>1</sup>

(In Metric Tons.)

Country.	1910.	1911.	1912.	1913.
United States.....	492,712	491,634	563,260	557,387
Mexico.....	62,504	61,884	73,617	52,815
Canada.....	23,810	25,570	34,213	34,587
Cuba.....	3,538	3,753	4,393	3,417
Australasia.....	* 40,962	* 42,510	* 47,772	* 45,300
Peru.....	* 27,375	28,500	26,483	25,715
Chile.....	38,346	33,088	39,204	40,195
Bolivia.....	3,212	2,950	4,681	* 5,000
Japan.....	* 50,703	* 52,303	* 62,486	* 65,000
Russia.....	* 22,700	* 25,747	* 33,550	* 44,000
Germany.....	* 25,100	* 22,363	* 24,303	* 25,000
Africa.....	* 15,400	* 17,252	* 16,632	* 20,000
Spain and Portugal.....	* 51,100	* 52,878	* 59,873	* 52,300
Other countries.....	* 24,888	* 26,423	* 29,555	* 30,000
Totals.....	882,351	886,855	1,020,022	1,000,716

<sup>1</sup> The statistics in this table are from the Engineering and Mining Journal, except where specially noted to the contrary. \* As reported by Henry R. Merton & Co. \* As officially reported. \* Privately communicated to us from Japan. \* As communicated by our correspondents. \* Shipments to Europe. \* Estimated.

. PRODUCTION OF COPPER IN THE UNITED STATES.<sup>1</sup>

According to class. (In pounds.)

Year.	Lake.	Electrolytic. <sup>2</sup>	Casting. <sup>3</sup>	Pig copper. <sup>4</sup>	Total.
1904	208,329,248	705,478,400	* 45,000,000	44,408,000	1,003,215,648
1905	219,000,000	* 760,000,000	46,000,000	33,495,000	* 1,058,494,000
1906	224,071,000	* 860,000,000	52,000,000	29,098,000	* 1,165,169,000
1907	220,317,041	854,441,000	47,957,000	30,032,000	1,152,747,890
1908	222,267,444	850,660,325	44,967,250	35,000,000	1,152,895,019
* 1909	226,602,134	1,101,518,458	67,471,446	43,159,018	1,438,751,056
* 1910	221,400,864	1,151,624,597	* 55,673,196	49,903,463	1,475,602,120
1911	216,412,867	1,156,627,311	22,977,534	35,920,626	1,431,938,338
1912	231,628,486	1,288,333,298	24,777,266	37,181,237	1,581,920,287
* 1913	161,000,000	1,390,000,000	25,000,000	39,000,000	1,615,000,000

<sup>1</sup> From Metal Statistics, 1914. \* Exported. \* Estimated. \* Partly estimated. \* Included copper from scrap and junk. \* The statistics for 1909 are officially communicated by the Copper Producers' Association, except that to its report of 34,123,446 lbs. of casting copper there has been added 33,348,000 lbs. reported by the junk smelters. The term "Lake" copper is here used to designate all copper sold in the trade as such regardless of the process by which it is refined. \* Copper Producers' Association through Engineering and Mining Journal, May 6, 1911. \* Includes 23,480,000 lbs. from scrap.



## MINERAL RESOURCES OF MICHIGAN.

## STATISTICS OF REFINED COPPER, 1913.

The accompanying table taken from the Engineering and Mining Journal embraces the reports of the Copper Producers' Association and the stock of standard copper, which is reported semi-monthly from Europe.

Month.	United States.			Visible stocks.		
	U. S. refinery production.	Deliveries, domestic.	Deliveries, for export.	United States.	Europe.	Total.
Year 1912.....	1,581,920,287	819,665,948	746,396,452	.....	.....	.....
I, 1913.....	143,479,625	65,210,030	60,383,845	105,312,582	78,491,840	183,904,422
II.....	130,948,881	59,876,492	72,168,523	123,198,332	77,504,000	200,702,332
III.....	136,251,849	76,585,471	77,699,306	122,302,890	81,244,800	203,547,690
IV.....	135,353,402	78,158,837	85,894,727	104,269,270	87,180,800	191,450,070
V.....	141,319,416	81,108,321	68,285,978	75,549,108	85,948,800	161,497,908
VI.....	121,860,853	68,362,571	68,067,901	67,474,225	77,235,200	144,709,425
VII.....	138,074,602	58,904,192	78,480,071	52,814,606	71,904,000	124,808,606
VIII.....	131,632,362	73,649,801	73,263,469	53,591,945	66,420,480	120,015,385
IX.....	131,401,229	66,836,897	73,085,275	38,314,037	63,716,800	102,030,837
X.....	139,070,481	68,173,720	68,123,473	29,793,094	53,625,600	83,418,692
XI.....	134,087,708	48,656,858	70,067,803	32,566,382	48,787,200	81,353,582
XII.....	.....	.....	.....	47,929,429	46,592,000	94,521,429
Year, 1913.....	.....	.....	.....	.....	.....	.....
I, 1914.....	.....	.....	.....	.....	53,910,800	.....

Note.—From January 1, 1913, visible supplies in Europe do not include copper afloat.

## COPPER INDUSTRY.

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PRODUCTION OF COPPER IN THE UNITED STATES IN 1912 AND 1913.<sup>1</sup>

(Smelter output, in pounds fine.)

	1912.	1913.
Alaska.....	31,926,209	23,423,070
Arizona.....	359,322,096	404,278,809
California.....	31,516,471	32,492,265
Colorado.....	7,963,520	9,052,104
Idaho.....	7,182,185	8,711,490
Maryland.....	53,043	.....
Michigan.....	231,112,228	155,715,286
Missouri.....	440,725	576,204
Montana.....	308,770,826	285,719,918
Nevada.....	83,413,900	85,209,536
New Mexico.....	29,170,400	50,196,881
North Carolina.....	63,766	180
Oklahoma.....	.....	11
Oregon.....	311,860	77,812
Pennsylvania.....	248,378	245,337
Phillipine Islands.....	.....	22
South Dakota.....	23,657	4,549
Tennessee.....	18,395,256	19,489,654
Texas.....	964	39,008
Utah.....	132,150,052	148,057,450
Vermont.....	.....	5,771
Virginia.....	96,753	46,961
Washington.....	1,069,938	732,742
Wyoming.....	25,080	362,235
Undistributed.....	11,413	46,803
Totals.....	1,243,268,720	1,224,484,098

<sup>1</sup> From U. S. G. S. report by B. S. Butler.



## THE IRON ORE RESERVES OF MICHIGAN.

BY R. C. ALLEN.

## A BRIEF DESCRIPTION OF THE IRON BEARING FORMATIONS.

## CHARACTER OF THE IRON FORMATIONS.

The iron formations, in which the iron ore bodies are found, are sedimentary rocks composed, in an unaltered condition, chiefly of silica in the form of chert and quartz, and the iron bearing minerals, ferrous carbonate (siderite), ferrous silicate (greenalite) and iron oxide (mainly hematite). Oxidation has transformed most of the ferrous iron contents to iron oxide in the exposed parts of the formations producing ferruginous cherts ("soft ore jasper"), ferruginous slates and, by further metamorphism (anamorphism) jaspilites ("hard ore jasper"). If oxidation is complete and the silica content sufficiently reduced by leaching, ore bodies result.

## RELATIONS TO OTHER FORMATIONS.

The iron formations are interbedded with other sedimentary rocks, mainly slate and quartzite, and in some places with basic igneous rocks of contemporary volcanic origin. In some areas they are cut by dikes and irregular masses of younger intrusive basic igneous rocks, notably in the Gogebic and Marquette districts, and to lesser extent in all of the other districts.

The names of the iron bearing formations and their age relationships are given below.

	Keweenawan.	
Algonkian..	Huronian Series.	Upper—Ironwood formation of the Gogebic range. Vulcan formation of Iron River, Crystal Falls and Menominee districts and Bijiki iron bearing member of Marquette district. Middle—Negaunee formation of Marquette and Gwinn districts. Lower—
Archean...	Keewatin Series.	
	Laurentian Series.	

## THICKNESS OF THE IRON FORMATIONS.

The iron bearing beds vary greatly in thickness in the different ranges. In the Gogebic district the maximum thickness is 800 to 1,000 feet, in the Marquette district from 1,000 to possibly 1,500 feet, in the Iron River and Crystal Falls districts not more than 350 feet to 400 feet, and in the Menominee district the combined thickness of the two productive beds varies on the average between 300 feet and 400 feet.

## DEFORMATION AND ALTERATION OF THE IRON FORMATIONS.

Originally deposited in about flat lying or horizontal position, the iron bearing beds and associated rocks were subsequently folded by compressive earth movements into synclines (troughs) and anticlines (arches). During deformation the formations were not only folded but fractured, and along many of these fractures faults or displacements occurred. Deformation of the iron formations was mainly accomplished while they were buried beneath overlying formations but erosion has since partially removed the overlying rocks.

## FORMATION OF THE ORE BODIES.

The ore bodies are concentrations of iron oxide in exposed parts of the richer layers of the iron formation. They are further very largely limited in occurrence to places where structural conditions combine with other factors to render the agents of alteration exceptionally effective. The main agent of alteration is oxygenated and carbonated meteoric water. The waters descend from the surface oxidizing the ferrous carbonate and silicate to ferric oxide and leaching out the silica. Those parts of the iron formation most happily situated to receive a vigorous circulation of oxidized and carbonated waters are more apt to carry ore bodies than parts not so situated. Concentration of downward moving meteoric waters is favorably influenced by certain structural conditions such as (1) the occurrence of impervious foot walls of slate or other rocks, (2) pitching troughs with impervious basements, (3) an inclined position of the iron formation, (4) a brecciated or porous condition of the iron formation, (5) a large area of the iron formation exposed at the surface. *Ferruginous chert* and *ferruginous slate* are iron formation rocks which represent a part way stage between the unaltered phase and iron ore. In them the original ferrous carbonate and ferrous silicate minerals are partly or wholly oxidized to ferric oxide but the silica has not been removed. Rocks thus altered make up the great bulk of the accessible parts of the iron formations.

## DEPTH TO WHICH IRON ORE OCCURS.

Nearly all of the ore bodies are exposed at the rock surface. Those deposits which are not exposed at the rock surface are connected with this surface by ferruginous chert or slate, that is to say, by rocks which have been altered by processes which if completed would result in ore concentration. Ore deposits may be expected to occur to depths to which an active circulation of oxidizing waters has penetrated. Obviously such depths will depend on factors of uncertain character which vary widely in different localities. For these reasons speculation as to the maximum depth at which ore will ultimately be found is hazardous to say the least. The ultimate maximum depth at which iron ores may be found and from which they may be profitably mined has not been attained.

## IMPORTANCE OF THE MICHIGAN IRON MINING INDUSTRY.

For nearly a half century prior to 1901 the annual production of iron ore in Michigan exceeded that of any other state. Since the year 1900 the production in Minnesota has been greater than that in Michigan, and is now fully two-thirds of the tonnage annually mined in the Lake Superior region and more than half of the total production of the United States. Notwithstanding the overwhelming magnitude of the Minnesota production in recent years Michigan had shipped at the end of 1913, 40.6 per cent (255,565,856 tons) of the total tonnage mined in the Lake Superior region, and about 21.5 per cent of the entire tonnage mined in the United States in all years. Compared with nearly all of the other producing districts of North America the Lake Superior ores are high grade and were the figures in the following table expressed in weight of metallic iron rather than tons of ore the importance of the Lake Superior region would appear even greater, vastly preponderating as it is under any basis of comparison.

## MINERAL RESOURCES OF MICHIGAN.

COMPARATIVE TABLE SHOWING PRODUCTION OF IRON ORE IN THE UNITED STATES, THE LAKE SUPERIOR REGION AND MICHIGAN.

	Total <sup>1</sup> shipments Lake Superior Region. Long tons.	Total <sup>1</sup> production United States. Long tons.	Total <sup>1</sup> shipments Michigan. Long tons.	Per cent total.		Percent of Lake Superior Region. Michigan.
				Lake Superior Region.	Michigan.	
1854	3,000		33,000 <sup>1</sup>			100
1855	1,449		1,449			100
1856	36,343		6,343			100
1857	25,646		25,646			100
1858	15,876		22,876			100
1859	68,832		68,832			100
1860	114,401	2,973,400	114,401	4.0	4.0	100
1861	49,909		49,909			100
1862	124,169		124,169			100
1863	203,055		203,055			100
1864	243,127		243,127			100
1865	236,208		186,208			100
1866	278,796		278,796			100
1867	473,567		443,567			100
1868	491,440		491,454			100
1869	617,444		617,144			100
1870	830,940	3,831,891	830,934	21.7	21.7	100
1871	779,607		779,607			100
1872	900,901		893,169			100
1873	1,162,458		1,153,249			100
1874	919,557		919,257			100
1875	891,257	4,017,857	889,477	22.2	22.2	100
1876	992,764		1,006,785			100
1877	1,015,087		1,010,494			100
1878	1,111,110		1,023,083			100
1879	1,375,691		1,130,019			100
1880	1,908,745	7,120,362	1,384,010	26.8	19.5	72.5
1881	2,306,505	7,119,643	2,121,558	32.4	29.8	91.8
1882	2,965,412	8,700,000	2,689,395	34.1	30.9	90.6
1883	2,353,288	8,800,000	2,291,115	26.7	26.0	97.3
1884	2,518,692	7,718,129	2,420,068	32.6	31.3	96.1
1885	2,466,372	7,600,000	2,192,243	32.4	28.8	88.8
1886	3,568,022	10,000,000	3,157,213	35.7	31.6	88.5
1887	4,730,577	11,300,000	4,004,328	41.8	35.4	85.5
1888	5,063,693	12,062,530	4,159,780	41.9	34.4	82.1
1889	7,292,754	14,518,041	5,660,495	50.2	38.8	77.6
1890	9,012,379	16,036,043	7,144,290	56.2	44.6	79.3
1891	7,062,233	14,591,178	5,754,339	48.5	39.4	81.4
1892	9,069,556	16,296,666	7,166,429	55.6	43.8	79.0
1893	6,060,492	11,587,829	4,417,155	52.3	38.1	72.6
1894	7,748,932	11,879,679	4,633,308	65.2	39.0	59.7
1895	10,429,037	15,957,614	5,916,026	65.4	37.1	56.7
1896	9,934,828	16,005,449	5,469,851	62.1	34.1	55.1
1897	12,469,638	17,518,046	6,381,301	71.1	36.4	51.1
1898	14,024,673	19,433,716	7,375,310	72.1	37.8	52.5
1899	18,251,804	24,683,173	9,307,585	73.0	37.7	50.8
1900	19,059,393	27,553,161	9,072,109	69.1	32.9	47.5
1901	20,589,237	28,887,479	9,190,349	71.3	31.8	44.6
1902	27,571,121	35,554,135	11,255,287	77.5	31.6	40.8
1903	24,289,878	35,019,308	9,154,147	69.3	26.1	37.6
1904	21,822,839	27,644,330	7,805,880	78.0	28.2	35.7
1905	34,384,116	42,526,133	11,684,432	80.8	27.4	33.9
1906	36,565,762	47,749,728	12,149,451	80.7	25.4	31.5
1907	42,266,668	51,720,619	12,166,929	81.7	23.5	28.7
1908	26,014,987	35,983,336	7,302,060	72.2	20.3	28.1
1909	42,586,869	51,294,271	12,251,965	83.0	23.8	28.7
1910	43,442,397	57,014,906	11,955,105	76.3	20.9	27.5
1911	32,793,130	43,876,552	8,898,327	74.7	20.3	27.1
1912	48,221,546	55,150,147	12,867,568	87.4	23.3	26.6
1913	49,947,116	59,643,098	12,677,466	83.75	21.25	25.4
Total.	623,755,334		255,565,856			49.6

<sup>1</sup>Includes 30,000 tons for years unknown.<sup>2</sup>Iron Trade Review.<sup>3</sup>Monograph No. 52, U. S. G. S. and Iron Trade Review.<sup>4</sup>Mineral Resources of the United States, U. S. G. S. and Michigan Geological Survey.

NOTE.—There are disagreements for early years in the first and third columns of figures taken from different sources. Prior to 1880 Michigan produced the entire Lake Superior output.

## PERMANENCY OF THE IRON MINING INDUSTRY IN MICHIGAN.

Michigan iron mining dates from the year 1845 when 300 pounds of ore were carried out from the Jackson mine at Negaunee and made into a bar of iron in a blacksmith's forge at Jackson. Twenty years later the annual production had risen to 1,000,000 tons; in forty years to more than 2,000,000 tons, and in sixty years to between 11,000,000 and 12,000,000 tons; at the end of 1913 the total production had risen to 255,565,856 long tons.

If all of the openings which were excavated in ore in mining the total production of Michigan were thrown together to form a single void of cubical form each of its three dimensions would approximate 1452 feet, or a little over one-fourth mile. The available iron ore reserves of Michigan at the end of 1913 have in the ground in their natural condition a volume of about 2,424,000,000 cubic feet, which is equivalent to a cube whose dimensional index is about 1343 feet, or about one-fourth mile. For each 14 tons of ore mined since 1844, 13 tons still remain in the ground accessible for mining; in other words, the acceleration in production, rapid as it has been, has been fully counterbalanced by acceleration in discovery and development. There is now available for mining almost as much ore as has been shipped in all preceding years.

Were exploration and discovery to cease at once, production at the average rate for the year preceding 1914 would exhaust the known reserves in a little more than 17 years; corresponding figures for 1911 and 1913 are 15.2 years and 17.7 years respectively. Up to the present year the reserves have been maintained well in advance of production. Contrary to the popular notion, there seems to be no sufficient reason for believing that this condition will be reversed in the near future, barring of course the possible effect of free foreign competition or other legislation unfavorable to mining and development of iron ore. The basis of this opinion rests on (1) the assured development of large ore reserves at deeper levels than have yet been attained in mining, (2) expected developments in unexplored and partially explored mineral lands, (3) reopening of abandoned properties, and (4) the future utilization of low grade ores.

## MINING AT DEEP LEVELS.

The results of deep level exploration have in recent years been decidedly reassuring. This is especially true on the Gogebic and Marquette ranges. Large bodies of high grade ore have been opened under 2,000 feet in depth on the Gogebic range. The average depth of the mines on this range is now 1,385 feet, and so encouraging is the outlook for deep level mining that underground exploration at deep levels through expensively constructed shafts is no longer con-



sidered unworthy of serious consideration, as it was a decade ago. Recent drilling on the Marquette range has demonstrated that ore exists, probably in great volume, at depths near 3,000 feet. In Iron county exploration has not progressed below 1,800 feet, but ore bodies are known to occur near this depth with presumption in favor of still greater depths. Many years will elapse before deep level exploration will be generally necessary to maintain reserves for there still remains in drift covered areas and partially explored parts of easily accessible iron formations untested possibilities from which new tonnages are being annually developed.

#### DEVELOPMENT OF UNEXPLORED MINERAL LANDS.

At the end of the year 1913, 71,726,559 tons of ore, equivalent to about one-third of the total reserves, was available for mining in undeveloped properties. The amount of ore which will ultimately be produced from these properties is, on the whole, much greater than it is possible to measure with assurance in their present condition, although some of them have been so thoroughly developed by drilling that fairly close estimates may be made.

#### TONNAGE OF RESERVES ESTIMATED IN UNDEVELOPED IRON PROPERTIES IN MICHIGAN. (DOES NOT INCLUDE PROSPECTIVE ORE IN DEVELOPED MINES.) JANUARY 1, 1913.

	Tons.
Gogebic Range.....	15,610,663
Iron County: (Iron River Dist.) (Crystal Falls Dist.).....	35,266,799
Menominee Range: (Dickinson Co.).....	None
Marquette Range: (Baraga Co.) (Marquette Co.).....	20,849,297
State of Michigan.....	71,726,559

In addition to the acreages in which minable ore bodies are known to exist there are 2,392 separate descriptions of land comprising 94,951 acres wherein there are known possibilities for the occurrence of ore bodies. In the light of present information these lands may be divided into three classes which, in the order of relative probability for ore occurrence, may be denominated, class A, class B and class C.

#### CLASSIFICATION OF IRON MINERAL LANDS IN MICHIGAN JANUARY 1, 1914, EXCLUDING ACTIVE MINES AND LANDS KNOWN TO BE ORE BEARING.

County.	Number of Descriptions.			Acres.		
	Class A.	Class B.	Class C.	Class A.	Class B.	Class C.
Gogebic.....	71	45	93	2,825.62	1,781.31	3,651.92
Iron.....	202	29	418	7,673.98	1,200.00	16,992.25
Dickinson.....	153	21	221	6,225.16	840.00	8,924.78
Marquette.....	666	213	.....	27,902.15	6,503.27	.....
Menominee.....	.....	.....	228	.....	.....	9,160.75
Delta.....	.....	.....	32	.....	.....	1,270.08
<b>Total.....</b>	<b>1,092</b>	<b>308</b>	<b>992</b>	<b>44,626.91</b>	<b>10,324.58</b>	<b>39,999.78</b>

With the progress of information it is certain that the total acreage of mineral lands will be increased, but in the meantime a considerable acreage will be eliminated through exploration. A very long time will elapse before the mineral lands are adequately prospected, but exploration is annually demonstrating that large tonnages in these lands await discovery. They constitute a main source of future production.

#### OPENING OF ABANDONED MINES.

At the end of 1913 there were no less than 120 abandoned mines that had formerly made ore shipments, 80 iron mines were active and 21 temporarily idle. Of the 65 undeveloped properties containing proven ore bodies, 24 were active and 41 were idle. Of the 58 unfinished explorations 19 were in progress and 39 were suspended.

CLASSIFIED NUMBERS OF ACTIVE, IDLE, AND ABANDONED IRON PROPERTIES IN MICHIGAN JANUARY 1, 1914.

Range.	Developed mines.		Undeveloped with proven ore bodies.		Explorations.		Abandoned mines.
	Active.	Idle.	Active.	Idle.	Active.	Idle.	
Gogebic.....	23	1	8	4	2	3	13
Iron Co.....	19	9	11	21	10	20	24
Menominee.....	10	4	0	0	1	10	24
Marquette.....	28	7	5	16	6	5	59
State.....	80	21	24	41	19	39	120

The changing conditions of the iron trade, gradually decreasing average tenor of shipments from the Lake Superior region, progress in beneficiation of low grade ores, demonstrated possibilities of deep level mining, the recurrence of periods of relatively easy finance, not to mention general advances in the science of mining engineering and in geologic knowledge, have made possible from time to time the resumption of activities on properties formerly abandoned. A number of such resumptions have occurred in recent years, some are in progress at the present time, and it is to be expected that a relatively large proportion of abandoned properties will in the course of time receive thorough exploration by modern methods. Many of the abandoned properties, particularly some of those which were abandoned in early years will be regenerated. No well informed person will fail to consider these properties, taken as a whole, as an important source of future production.

## UTILIZATION OF LOW GRADE ORES.

The tonnage estimates which have been referred to above include only those grades of ore which are marketable under current conditions of the iron trade. In commercial practice the definition of iron ore varies from year to year with a well marked general tendency towards the inclusion of lower and lower grades of iron bearing rock. For any particular mine the definition of iron ore varies with the sale price of the available grades and cost of production. The grade of iron bearing rock that may be profitably marketed is not the same in a given year in all districts, nor for all mines in any district. A year of lessened demand or of low prices, such for instance as 1914, always curtails the production of low grade ore and invariably forces the suspension of many mines which have only the low grades in reserve. But although demand and price, and consequently the tenor of the average output, fluctuate from year to year, the increasing ratio of iron consumption to available high grade ore reserves is gradually lowering the tenor of ore marketed from the Lake Superior region. A measure of this tendency is afforded in the following table compiled by W. L. Tinker, Secretary of the Lake Superior Iron Ore Association.

AVERAGE IRON CONTENT OF LAKE SUPERIOR IRON ORE SHIPMENTS 1902-12.  
ALL RANGES.

Year.	Tonnage.	Per cent average (Natural.)
1912.....	44,365,100	51.9603
1911.....	30,255,438	51.8869
1910.....	41,172,143	52.0703
1909.....	40,552,405	52.1130
1908.....	24,774,568	52.9551
1907.....	38,574,136	53.4020
1906.....	36,179,170	53.8552
1905.....	32,353,475	54.6072
1904.....	20,529,719	55.5791
1903.....	22,357,876	55.5049
1902.....	24,930,701	56.2233

The average yearly decline in iron content for the period 1902-12 is .4263 per cent, or 4.263 per cent for the decade. It is obvious of course that this decline must cease at some future period.

There is no doubt among students of fundamental conditions that ores of very low grade will eventually have to be mined in the Lake Superior region. Experiments in the beneficiation of the various types of Lake Superior ores are already under way. From what has been accomplished it begins to be apparent that nearly all types of Lake Superior low grade ores will be subject to beneficiation at the mines. Wet concentration methods are now in use on tremendous

scale by the Oliver Iron Mining Company near Coleraine, Minnesota, while other plants are located near Nashwauk and at the Madrid mine near Virginia, Minnesota, and also at the American-Boston mine at Diorite, Michigan. In Canada magnetic concentration is successfully operating at the Moose Mountain mine, near Sudbury, and at the Magpie mine, on the Michipicoten range, low grade carbonate ore is treated in rotary kilns. A number of other plants are planned on the Lake Superior ranges.

It is needless to remark that each decline of one per cent in the average iron content of ores mined adds millions of tons to the ore reserves. How far this decline will be forced cannot be foreseen. An issue of immediate and growing concern refers to encroachment of foreign ore into territory which heretofore has been tributary to the Lake Superior mines. This question has a bearing on the matter under discussion, but its complexity does not admit of its consideration here. When the time shall come for general utilization of the low grade iron bearing rocks from the Lake Superior region the Michigan reserves alone will be ample for the needs of the country for generations. The supply is so enormous that estimates at this time have no significance.

#### RECENT ESTIMATES OF MICHIGAN IRON ORE RESERVES.

Careful estimates of the iron ore reserves of Michigan are made annually under the direction of the Board of State Tax Commissioners. The first estimate was made in 1911 by C. K. Leith; the estimates for 1913 and 1914 were made by the writer assisted by Mr. O. R. Hamilton.

The reserves are divided into two classes, viz.: developed ore and prospective ore. The developed ore is that which is expressed by mining engineers by the term "ore in sight" and is limited to ore blocked out above bottom levels in developed mines. The prospective ore is included in undeveloped properties, extensions below bottom levels, and in some cases lateral extensions of partially developed mine levels.

Inasmuch as each of the three estimates above referred to were made by the use of the same methods the resulting totals may be considered strictly comparable. The managers, superintendents and engineers of the various mines should be credited with the indispensable aid which they rendered in the work of each of these tonnage estimates.

## IRON ORE RESERVES OF MICHIGAN.

Range.	1911.		1913.		1914.	
	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.
Gogebic county .....	18,296,721	13,308,279	23,813,191	7,754,388	23,765,158	21,113,192
Iron county .....	7,934,687	25,682,155	13,249,683	47,536,233	13,337,913	45,045,227
(Iron River District) (Crystal Falls District) .....						
Menominee .....	9,082,750	2,567,700	9,682,994	3,100,458	11,062,700	2,129,950
(Dickinson county) .....						
Marquette .....	36,228,742	56,473,068	34,692,034	51,529,275	33,095,467	47,919,718
(Baraga county) (Marquette county) .....						
State .....	71,542,900	98,038,202	81,437,902	109,920,354	81,261,238	116,208,087
Total .....	169,581,102		191,358,256†		197,460,325*	

\*Of date Jan. 1, 1914 in addition to which there was in stock 4,954,830 tons of ore, making a grand total of 202,424,155 tons  
†Of date Jan. 1, 1913 in addition to which there was in stock 4,366,349 tons of ore, making a grand total of 195,721,605 tons

Increase over estimate of preceding year .....

6,693,550 tons

## ROYALTY AND OWNERSHIP.

The term *royalty* refers to payment by operators for the ore in properties of which they own a part or none of the mineral value. The royalty is proportionate to the number of tons of ore shipped and is calculated on a flat or a graded rate per ton, or a combination of the two. Nearly all of the modern leases provide for a graded royalty based on sale price of ore, or on its composition. The sum paid for the privilege of holding a lease is called the minimum royalty. The royalty paid by the operators on shipments is commonly charged against the minimum, but in the event that the amount is less than the stipulated minimum royalty the difference must be paid to the fee owner.

The ownership of more than three-fourths of the Michigan iron mines resides in *fee holders* in distinction from *operators*. In the period 1908 to 1913, 88 per cent of the producing mines paid royalties. There have been few recent transfers of title to minerals in undeveloped iron lands. Mainly because of the uncertainty of values, both owners and operators prefer to deal with these lands on a royalty basis under the leasing system.

Royalties which were actually paid by producing Michigan mines for the period 1908 to 1913 range from .864 cents to .055 cents per ton. Average royalties are highest on the Gogebic range, then follows in decreasing order the Marquette, Iron River-Crystal Falls, and Menominee ranges. The figures in the table below take no account of the partial ownership of minerals by operators of some of the royalty paying mines and are consequently somewhat lower than the average royalties expressed in leases. The figures are obtained by dividing the total royalties paid by the total tons shipped, excluding the mines wherein full ownership of minerals is vested in the operator.

ROYALTIES PAID BY MICHIGAN IRON MINES.  
1909-1913.

Range.	Number of producing mines.	Number of shipping mines paying royalty.	High.	Low.	Average per mine.	Average per ton mined.
Gogebic.....	26	26	.52723	.22372	.37633	.34765
Iron River—Crystal Falls.....	32	32	.54279	.08142	.28393	.23148
Menominee including Metropolitan & Calumet.....	15	15	.36077	.05494	.24198	.23605
Marquette—Gwinn.....	36	23	.86400	.02766	.44452	.19877
State.....	109	96			.34105	.25249

In the five years preceding 1914, 109 mines controlled by 64 operating companies including subsidiaries made shipments; of these 96 paid royalties. The Oliver Iron Mining Co. of the United States Steel Corporation is the largest shipper but does not hold the position of preponderance in Michigan as it does in the Lake Superior region in general, as shown in the table below. Of the total reserves in 1914, 46,547,454 tons, or 22.9 per cent, is controlled by the Oliver Iron Mining Company while 155,876,701 tons, or 77.1 per cent, is controlled by 16 other companies. The number of independent companies becomes 57 if the larger organizations are broken up into their subsidiaries.

MICHIGAN IRON ORE RESERVES BY RANGES. 1914.

Range.	Total reserves (including ore in stock) Jan. 1, 1914. Tons.	Controlled by U. S. Steel Corporation. Tons.	Per cent.	Controlled by other companies. Tons.	Number of other companies.	Per cent.
Gogebic.....	45,785,870	13,000,664	28.4	32,785,206	10	71.6
Iron Co.: Iron River & Crystal Falls Dists.....	59,468,551	2,777,455	4.6	56,691,096	26	95.4
Menominee Range. (Dickinson Co.).....	13,778,283	5,831,845	42.3	7,946,438	7	57.7
Marquette: Baraga Co. Marquette Co.....	83,391,451	24,937,490	29.9	58,453,961	19	70.1
State.....	202,424,155	46,547,454	22.9	155,876,701	57	77.1

VALUE OF MICHIGAN IRON ORE, 1913.

The figures annually reported to the Michigan State Tax Commission afford the means of ascertaining with accuracy the value of Michigan ore at any stage in the process of mining and marketing, from its natural location in the ground to points of delivery. The following table shows the calculation of value of Michigan ore by ranges f. o. b. mine in 1913.

TO ASCERTAIN VALUE OF 1913 IRON ORE SHIPMENTS.

Range.	Gross receipts.	"Beyond the mine" charges.	Net receipts (f. o. b. at mine.)	1913 shipment.	Value per ton.
Gogebic.....	\$15,960,386 61	\$4,117,877 71	\$11,842,508 90	3,836,739	\$3 08
Iron River and Crystal Falls.....	8,688,761 74	2,248,845 02	6,439,916 72	3,088,591	2 08
Old Menominee.....	5,308,965 51	1,227,781 23	4,079,184 28	1,708,847	2 38
Marquette.....	11,708,799 80	2,687,628 19	9,021,171 61	3,790,566	2 38
State.....	\$41,664,913 66	\$10,282,132 15	\$31,382,781 51	12,424,743	\$2 52

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**STATISTICAL TABLES.**

**IRON ORE.**

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MICHIGAN IRON ORE RESERVES. 1914.

Range.	Data of bottom levels.		Total reserves.		Ore in stock. (Tons.)		Total tonnage Jan. 1, 1914. In mine and in stock.
	Average depth.	Total areas in ore in sq. ft.	Developed (Tons).	Prospective (Tons).	Jan. 1, 1914.	April 13, 1914.	
Gogebic.....	1,385 ft.	1,228,574	23,765,158	21,113,192	907,520	1,947,820	45,785,870
Iron County:							
Iron River and Crystal Falls Distats....	571 ft.	2,954,947	13,337,913	45,045,227	1,085,411	1,571,789	59,468,551
Old Menominee Range:							
Dickinson County.....	700 ft.	223,458	11,062,700	2,129,950	585,633	942,167	13,778,283
Marquette:							
Baraga and Marquette Counties.....	751 ft.	3,638,861	33,095,467	47,919,718	2,376,266	3,215,717	83,391,451
State.....	855 ft.	8,045,840	81,261,238	116,208,087	4,954,830	7,677,493	202,424,155

Tonnage of reserves estimated in undeveloped properties. (Does not include prospective ore in developed mines.)

Gogebic Range.....	Tons
Iron County: Iron River District and Crystal Falls District.....	15,610,463
Menominee Range: (Dickinson County).....	35,266,799
Marquette Range: (Baraga County and Marquette County).....	None
State of Michigan.....	20,849,297
	71,726,559

## MINERAL RESOURCES OF MICHIGAN.

## IRON MINES OF MICHIGAN

Range.	Number of mines.		Total			
			1908-1912.			1909-
	1908 1912.	1909 1913.	Sold.	Shipped.	Mined.	Sold.
1 Marquette.....	40	39	16,949,856	17,180,239	18,726,164	17,943,337
2 Gogebic.....	28	29	14,446,149	15,738,980	15,880,973**	16,368,429
3 Menominee.....	17	17	7,957,359	7,984,566	8,399,659	8,258,229
4 Iron River and Crystal Falls...	32	33	11,519,398	11,432,037	12,141,845	13,353,799
State.....	117	118	50,872,762*1	52,345,822	55,148,641**	55,923,794

\*1 Does not include (1) Ashland, (2) Volunteer.

\*\*2 Total used to obtain cost per ton is 14,790,125.

\*\*3 Total used to obtain cost per ton is 54,057,793.

TABLE OF COSTS.

Tonnage.		Total cost.		Cost per ton mined.	
1913.		1908-1912.	1909-1913.	1908-1912.	1909-1913.
Shipped.	Mined.				
18,160,784	19,299,746	x\$45,905,800 49,358,704	\$51,428,569 14	x\$2.63 2.63581	\$2.58401 1
16,354,717	16,480,159	x40,090,621 41,817,840	47,037,450 88	x2.75 2.82741	2.86218 2
8,221,139	8,433,188	x20,869,922 21,063,259	20,752,050 74	x2.50 2.50764	2.47865 3
13,215,389	13,751,488	x25,402,166 28,506,589	31,919,664 20	x2.23 2.34779	2.35158 4
55,952,029	57,964,581	x\$132,268,509 140,746,392	\$151,137,734 96	x\$2.55 2.60362	\$2.63194

xTaken from Report of Appraiser of Mines to Board of State Tax Commissioners, 1913, page 22. These costs do not include costs reported by mines not on operating basis, but represent 96 per cent of total tonnage mined 1908-1912.

VALUE OF MICHIGAN IRON MINES.<sup>1</sup>

Range.	Total leased acreage appraised. Acres.	Previous appraisals.			1914 appraisal.		Combined value of mine and ore in stock.	Total tonnage in mine and in stock Jan. 1, 1914.	Assessed value per ton.
		1911.	1912.	1913.	Mine.	Ore in stock.			
Cogebie County: (Iron River and Crystal Falls Dist.)	5,987	\$28,338,100	\$27,226,300	\$25,849,873	\$30,355,700	\$4,311,328	\$34,667,028	45,785,870	\$0.7571
Menominee:	7,567	15,018,475	15,359,664	20,978,709	18,769,652	2,506,293	21,275,945	59,468,551	0.3577
Dickinson County:	3,585	7,427,500	7,240,625	6,641,925	4,749,120	1,663,883	6,413,003	13,778,283	0.4654
Marquette: Baraga and Marquette Counties:	8,003	34,745,000	31,270,500*	20,063,714	24,335,004	4,880,235	29,216,139	83,391,451	0.3503
State:	25,142	\$85,529,075	\$81,097,089	\$52,534,221	\$78,210,376	\$13,361,739	\$91,572,115	202,424,155	\$0.4524

<sup>1</sup>By Board of State Tax Commissioners.

\*Approximate figure.

STATISTICAL TABLES—IRON ORE.

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ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN STANDARD IRON ORES, 1855-1914.

Year.	Marquette Range.									
	Rail freight.		Boat freight.		Price at Lake Erie ports.		Value of ore at the mines.			
							Shipped via Marquette.		Shipped via Escanaba.	
	To Marquette.	To Escanaba.	From Marquette.	From Escanaba.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.
1855.	\$3 00		\$3 00		\$10 00	\$10 00	\$4 00	\$4 00		
1856.	1 27		3 00		8 00	8 00	3 73	3 73		
1857.	1 27		2 67		8 00	8 00	4 08	4 08		
1858.	87		2 09		6 50	6 50	3 54	3 54		
1859.	87		2 00		6 00	6 00	3 13	3 13		
1860.	1 09		2 00		5 25	5 50	2 16	2 41		
1861.	1 09		2 21		5 25	5 00	1 95	1 70		
1862.	1 09		2 89		5 25	5 37	1 27	1 39		
1863.	1 09		3 19		7 50	7 50	3 22	3 22		
1864.	1 09		3 37		8 50	8 50	4 04	4 04		
1865.	1 10		3 23		7 50	7 50	3 17	3 17		
1866.	1 10	\$1 55	4 17	\$3 77	9 50	4 23	4 23	8 69		
1867.	1 10	1 80	2 98	3 28	14 00	4 23	8 73	4 18		\$2 92
1868.	1 10	1 80	3 11	2 44	8 25	8 00	6 42	7 42	5 42	6 42
1869.	1 10	1 85	3 21	2 43	8 25	8 25	4 04	4 04	4 20	4 20
1870.	1 10	1 85	3 06	2 40	8 50	9 50	3 94	5 19	3 97	5 22
1871.	95	1 70	2 83	2 07	8 00	8 50	4 34	5 34	4 25	4 25
1872.	84	1 70	3 59	2 50	9 00	9 50	4 22	4 22	4 23	4 23
1873.	84	2 00	3 44	2 74	12 00	9 00	4 57	3 07	4 80	3 30
1874.	84	2 00	3 84		9 00	7 00	7 72	4 72	7 26	4 26
1875.	65	1 25	2 87		7 00	5 50	3 48	1 98		
1876.	55	1 15	2 54		6 75	4 50	3 66	1 41		
1877.	55	1 15	1 40		6 50	4 25	4 55	2 30		
1878.	55	1 15	1 26	85	5 50	4 25	3 69	2 44	3 50	2 25
1879.	55	1 15	1 61	1 07	6 25	4 75	4 09	2 59	4 03	2 53
1880.	55	1 25	2 50	1 77	9 25	8 00	6 20	4 95	6 23	4 98
1881.	55	1 25	2 25	1 55	9 00	7 00	6 20	4 20	6 20	4 20
1882.	55	1 25	1 50	1 22	9 00	6 25	6 95	4 20	6 53	3 78
1883.	55	1 10	1 30	1 11	6 25	5 00	4 40	3 15	4 04	2 79
1884.	40	80	1 21	98	5 76	4 50	4 15	2 80	3 98	2 72
1885.	45	80	1 01	84	5 50	4 25	4 04	2 79	3 86	2 61
1886.	55	80	1 35	1 16	5 50	4 75	3 60	2 85	3 54	2 79
1887.	55	80	1 75	1 49	7 25	5 25	4 95	2 95	4 96	2 96
1888.	45	70	1 22	97	5 50	4 75	3 83	3 08	3 83	3 08
1889.	45	70	1 14	1 00	5 50	4 50	3 91	2 91	3 80	2 80
1890.	45	70	1 16	99	6 75	5 75	5 14	4 14	5 06	4 06
1891.	45	70	96	74	6 00	4 74	4 59	3 34	4 56	3 31
1892.	40	65	1 06	87	5 50	4 85	4 04	3 30	3 98	3 33
1893.	40	65	85	70	4 25	3 00		1 75		1 65
1894.	32		70	53	2 75	3 50	3 00	2 25	2 90	2 15
						2 15	1 73	1 13		

## ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN STANDARD IRON ORES, 1855-1914.

(Continued.)

Year.	Marquette Range.									
	Rail freight.		Boat freight.		Price at Lake Erie ports.		Value of ore at the mines.			
							Shipped via Marquette.		Shipped via Escanaba.	
	To Marquette.	To Escanaba.	From Marquette.	From Escanaba.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.
1895.....	\$0 32	\$0 52	\$0 83	\$0 64	\$2 75 3 50	\$2 15 2 30	\$1 60 2 35	\$1 00 1 15	\$1 59 2 34	\$0 90 1 14
1896.....	32	52	80	61	4 00	2 45 2 85	2 88	1 33 1 73	2 78	1 32 1 72
1897.....	32	52	60	45	2 65	2 00 2 60	1 73 1 68	1 08	1 68	1 03 1 63
1898.....	32	40	60	48	3 10 3 35	2 35 2 45	2 18 2 43	1 43 1 53	2 22 2 47	1 47 1 57
1899.....	25	40	84	72	3 21 3 50	2 50	2 12 2 41	2 09 1 41	2 38	2 09 1 38
1900.....	25	40	94	85	5 93 6 48	5 00	4 74 5 29	4 68 5 23	4 68 5 23	3 75 4 28
1901.....	25	40	74	62	4 66 4 92	3 65 3 85	3 67 3 93	2 66 2 86	3 64 3 90	2 63 2 83
1902.....	25	40	68	59	4 65 5 00	3 80 4 00	3 72 4 07	2 87 3 07	3 66 4 01	2 81 3 01
1903.....	25	40	73	63	4 85 5 15	4 00 4 25	3 87 4 17	3 02 3 27	3 82 4 12	2 97 3 22
1904.....	25	40	61	54	3 60 3 85	3 10 3 35	2 74 2 99	2 24 2 49	2 66 2 91	2 16 2 41
1905.....	32	40	70	60	3 75	3 20	2 73	2 18	2 75	2 20
1906.....	32	40	70	60	4 25	3 70	3 23	2 68	3 25	2 70
1907.....	32	40	70	60	5 00	4 20	3 98	3 18	4 00	3 20
1908.....	32	40	60	50	4 50	3 70	3 58	2 78	3 60	2 80
1909.....	32	40	60	50	4 50	3 70	3 58	2 78	3 60	2 80
1910.....	32	40	65	55	5 00	4 20	4 03	3 23	4 05	3 25
1911.....	32	40	55	45	4 50	3 70	3 63	2 83	3 55	2 75
1912.....	30	40	45	35	3 75	3 00	3 00	2 25	3 00	2 25
1913.....	25	40	50	40	4 40	3 60	3 65	2 85	3 60	2 80
1914.....	25	40	45	35	3 75	3 00	3 05	2 30	3 00	2 25

STATISTICAL TABLES—IRON ORE.

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ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES  
OF MICHIGAN STANDARD IRON ORES, 1855-1914.

(Concluded.)

Year.	Menominee Range.						Gogebic Range.					
	Rail freight.	Boat freight.	Price of ore at Lake Erie ports.		Value of ore at the mines.		Rail freight.	Boat freight.	Price of ore at Lake Erie ports.		Value of ore at the mines.	
	To Escanaba.	From Escanaba.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.	To Ashland.	From Ashland.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.
1883	.....	.....	\$6 00	\$4 75	.....	.....	.....	.....	.....	.....	.....	.....
1884	.....	.....	5 25	4 50	.....	.....	.....	.....	.....	.....	.....	.....
1885	.....	.....	4 75	4 00	.....	.....	.....	.....	.....	.....	.....	.....
1886	.....	.....	5 25	4 50	.....	.....	.....	.....	.....	.....	.....	.....
1887	\$0 85	\$1 49	6 00	5 00	\$3 66	\$2 66	\$0 80	\$2 11	\$6 00	\$5 00	\$3 09	\$2 09
1888	75	97	4 75	4 00	3 03	2 28	70	1 34	4 75	4 00	2 71	1 96
1889	75	1 00	4 50	4 50	2 75	2 75	70	1 29	4 50	4 50	2 51	2 51
1890	.....	99	5 50	5 25	4 51	4 26	70	1 26	5 50	5 25	3 54	3 29
1891	70	74	4 50	4 25	3 06	2 81	65	1 05	4 50	4 25	2 80	2 55
1892	70	87	4 50	3 65	2 93	2 08	65	1 20	4 50	3 65	2 65	1 80
1893	70	70	3 85	3 20	2 41	1 76	65	88	3 85	3 20	2 32	1 67
1894	70	53	2 75	2 50	1 52	1 27	52	.....	.....	.....	1 44	1 19
1895	52	64	2 90	2 25	1 74	1 09	52	79	2 75	2 50	1 31	1 06
1896	52	61	4 00	2 70	2 87	1 57	52	96	2 90	2 25	1 42	77
1897	52	45	2 60	2 15	1 63	1 18	52	91	4 00	2 70	2 57	1 27
							45	.....	.....	.....	1 52	1 45
							52	63	2 60	2 15	1 07	1 00
1898	45	48	2 75	1 85	1 82	92	40	.....	.....	.....	84	1 69
1899	40	72	3 00	2 15	1 88	1 03	45	61	2 75	1 85	1 74	79
1900	40	85	5 50	4 25	4 25	3 00	40	95	3 00	2 15	1 65	80
1901	40	62	4 25	3 00	3 23	1 98	40	1 05	5 50	4 25	4 05	2 80
1902	40	59	4 25	3 25	3 30	2 26	40	84	4 25	3 00	3 01	1 76
								76	4 25	3 25	3 09	2 09
1903	40	63	4 50	3 60	3 47	2 57	40	83	4 50	3 60	3 27	2 37
1904	40	54	3 25	2 75	2 31	1 81	40	70	3 25	2 75	2 15	1 65
1905	40	60	3 75	3 20	2 75	2 20	40	76	3 75	3 20	2 59	2 04
1906	40	60	4 25	3 70	3 25	2 70	40	75	4 25	3 70	3 10	2 55
1907	40	60	5 00	4 20	4 00	3 20	40	75	5 00	4 20	3 85	3 05
1908	40	50	5 00	4 20	4 10	3 30	40	65	5 00	4 20	3 95	3 15
1909	40	50	4 50	3 70	3 60	2 80	40	65	4 50	3 70	3 45	2 65
1910	40	55	5 00	4 20	4 05	3 25	40	70	5 00	4 20	3 90	3 10
1911	40	45	4 50	3 70	3 55	2 75	40	60	4 50	3 70	3 50	2 70
1912	40	30	3 75	3 00	2 90	2 15	40	50	3 75	3 00	2 85	2 10
1913	40	40	4 40	3 60	3 55	2 70	40	55	4 40	3 60	3 45	2 65
1914	40	35	3 75	3 00	3 00	2 25	40	50	3 75	3 00	2 85	2 10



## MINERAL RESOURCES OF MICHIGAN.

## IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.

Name of Mine.	1904 and prior years.	1905.	1906.	1907.
American (Sterling).....	112,930		419	13,764
Ames.....	6,298			
Barnum (Cliff Shaft) <sup>1</sup> .....	801,851			
Bay State.....	16,637			
Bessemer (See Lillie).....				
Bessie.....	35,572	21,879	1,646	
Beaufort (Ohio).....	316,348	38,306		78,029
Blue (See Queen Group).....				
Boston (with American).....	62,542			
Braastad { Mitchell.....	136,636			
Winthrop.....	831,445			
Breitung No. 1.....				
Breitung Hematite No. 2.....	17,723		83,671	59,667
Buffalo <sup>2</sup> .....	217,730			
Cambria.....	1,557,361	81,791	40,628	135,145
Champion.....	4,095,609	64,680	115,007	107,577
Chase.....				
Chester (See Rolling Mill).....				
Chicago.....	9,012			
Cleveland <sup>3</sup> .....	2,306,298			
Cleveland Hematite (Included under Cleveland).....				
Cleveland Cliffs Group <sup>4</sup> .....	10,273,806	1,288,416	1,330,944	1,030,928
Columbia (Kloman).....	94,813			
Curry.....	16,671			
Dalliba (Phoenix).....	59,114			
Detroit.....	140,841			
Dexter.....	118,512			
Dey.....	2,709			
East Champion.....	76,002			
East New York.....	294,509	33,095		
Edison.....	893			
Edwards (See Sampson).....				
Empire.....				40,565
Erie.....	8,136			
Etna.....	1,091			
Fitch.....	31,817			
Foster <sup>5</sup> .....	171,893			
Foxdale.....	28,144	3,303		
Gibson.....	16,357			
Goodrich.....	49,754			
Grand Rapids (Davis).....	110,736			
Green Bay (See Bay State).....				
Hartford.....	222,734	322,209	364,801	328,161
Hortense (North Champion).....	30,574			
Home (P. and L. S.) (Now Volunteer).....	26,022			
Humboldt (Washington).....	713,961			
Imperial.....	150,489	1,661	5,076	55,756
Indiana (See Bay State).....				
Iron Cliffs <sup>6</sup> .....	1,700,537			
Iron Mountain.....	393			
Jackson.....	3,768,862	33,180	5,066	61,345
Keystone (See East Champion).....				
Lake <sup>10</sup> .....				
Lake Angeline.....	6,858,079	374,183	269,116	283,373
Lake Superior.....	12,283,058	727,378	635,671	674,066
Lillie.....	1,554,956	9,868	32,781	80,545
Lloyd.....				
Lucy (McComber).....	516,159		85	32,378
Maas.....			292	
Magnetic (Stock Pile).....				
Manganese (Negaunee).....	6,359			
Marquette <sup>7</sup> .....	152,847			
Mary Charlotte.....	83,188	221,738	257,088	155,633
Mesabi's Friend.....	16,043			
Michigamme <sup>8</sup> .....	880,362			

See foot notes 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 on pages 62 and 63.

STATISTICAL TABLES—IRON ORE.

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IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.

1908.	1909.	1910.	1911.	1912.	1913.	Totals.
23,222	90,001	163,290.	195,197	122,211	162,253	883,287
						6,298
						801,851
						16,637
						59,097
61,035	72,987	23,427	2,683			592,815
						62,542
						136,636
						831,445
55,849	129,673	114,202	63,497	57,085	30,994	151,576
			72,688	63,995	83,280	680,748
						217,730
85,977	136,815	150,422	85,954	69,904	169,153	2,513,150
313	11,199	18,746				4,413,131
					52,930	52,930
						9,012
						2,806,298
438,379	877,433	955,374	514,305	1,032,836	922,005	18,664,426
						94,813
						16,671
						59,114
						140,841
						118,512
						2,709
						76,002
						327,604
						893
53,537	108,993	53,687	16,954	33,124	38,348	345,208
						8,136
						1,091
						31,817
						171,893
						31,447
						16,357
						49,754
						110,736
278,366	250,680	183,471				1,950,422
						30,574
						26,022
48,231	115,478	83,404	86,959	53,943	37,543	713,961
						638,540
						1,700,537
						393
	11,060	40,320	22,303	53,559	1,519	3,997,214
220,410	280,298	244,923	167,258	151,910	102,762	8,952,312
261,955	349,435	271,445	167,352	169,326	164,834	15,704,520
8,632	61,708	10,121	25,597	26,119		1,810,327
			28,003	44,224	135,746	207,973
1,115	1,672	11,257	16,676	72,724		619,688
29,036	159,197	208,103	24,926	46,664	171,475	671,779
						292
						6,359
						152,847
99,104	240,433	197,522	340,335	250,700	262,431	2,108,172
						16,043
						880,362

## IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.—Continued.

Name of Mine.	1904 and prior years.	1905.	1906.	1907.
Miller.....				
Milwaukee-Davis.....	375,451			
Mitchell.....	17,780			
Moore.....	68,131			
Morris.....				
National.....	150,216			
Negaunee.....	2,328,519	239,554	253,448	196,170
Negaunee Construction Works.....	12,708			
New York (York).....	1,123,071			
New York Hematite.....	37,587			
North Champion (See Hortense).....				
North Republic.....	289			
Nonpareil (St. Lawrence).....	23,395			
Northwest.....	1,687			
Norwood.....	5,753			
Ogden.....	986			
Pascoe.....	59,806			
Pendill.....	45,993			
Palmer.....	1,041		13,131	
Palmer (Cascade) (See Volunteer).....				
Pioneer.....	15,409			
Pittsburg & Lake Angeline (See Lake Angeline).....				
Platt.....	73,844			
Portland.....				
Primrose.....	6,040			
Prince of Wales <sup>1</sup> .....	32,415			
Quartz.....	491			
Queen <sup>2</sup> .....	180,866			
Queen Group <sup>3</sup> .....	4,190,001	253,377	221,096	309,917
Republic.....	5,450,422	150,699	177,220	170,554
Republic Reduction Co.....	47,174			
Richards.....	8,261			
Richmond.....	314,047	86,129	89,563	35,156
Riverside.....	16,160			
Rolling Mill.....	315,660	28,766		49,204
Saginaw.....	451,421			
Salisbury <sup>4</sup> .....	686,411			
Sam Mitchell (See Mitchell).....				
Sampson (Argyle).....	267,805			
Schadt.....	1,261			
Section 12.....	21,887			
South Buffalo <sup>5</sup> .....	245,412			
Spurr.....	165,244			
Star West (Wheat).....	204,649			
St. Lawrence (See Nonpareil).....				
Sterling (See American).....				
Taylor.....	32,970			
Teal Lake (See Cambria).....				
Titan.....	90,371			
Volunteer (See Also Home).....	1,238,328	106,281	38,544	10,022
Washington.....				
Webster.....	34,905			
West Republic.....	133,077			
Wetmore.....	50,870			
Wheeling.....	433,771			
Winthrop <sup>6</sup> .....	1,335,839			
Wheat (See Star West).....				
Totals.....	71,781,840	4,086,493	3,935,293	3,907,955

<sup>1</sup>Under Iron Cliffs 1890-1895; under Cleveland-Cliffs group after 1895.<sup>2</sup>Under Queen group after 1890.<sup>3</sup>Under Cleveland-Cliffs group after 1883.<sup>4</sup>Includes Cleveland after 1883; includes Barnum, Foster, Iron Cliffs, Michigamme and Salisbury after 1895.<sup>5</sup>Under Iron Cliffs 1891-1895; under Cleveland-Cliffs group after 1895.<sup>6</sup>Under Queen group after 1890.

STATISTICAL TABLES—IRON ORE.

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IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.—Continued.

1908.	1909.	1910.	1911.	1912.	1913.	Totals.
			7,781	11,536	10,310	405,078
11,539		23,428	21,387	21,141	15,970	111,245
				1,529	18,394	68,131
						19,923
						150,216
232,219	312,217	348,818	140,040	442,190	327,447	4,820,622
						12,708
						1,123,071
						37,587
						289
						23,395
						1,687
						5,753
						986
						59,806
						45,993
						14,172
						15,409
	79,652	49,584				73,844
						129,236
						6,040
						32,415
						491
						180,866
104,098	237,509	230,119	295,962	224,862	235,648	6,302,589
67,999	176,575	150,732	113,137	156,867	135,879	6,750,084
						47,174
						8,261
60,994	102,566	95,772	47,293	117,873	138,394	1,087,787
						16,160
52,147	133,139	115,193	96,584	115,784	163,287	1,069,764
						451,424
						686,411
						267,805
						1,261
						21,887
						245,412
						165,244
						204,649
						32,970
						90,371
20,625	44,716	96,769	51,240	9,008	47,220	1,500,643
			62,010	66,540	60,171	350,831
						34,905
						133,077
						50,870
						433,771
						1,335,839
2,214,782	3,983,436	3,840,129	2,666,121	3,415,654	3,487,993	103,319,696

<sup>1</sup>Under Cleveland-Cliffs group after 1895.

<sup>2</sup>Under Winthrop after 1892.

<sup>3</sup>Includes Buffalo, Prince of Wales, Queen and South Buffalo after 1890.

<sup>4</sup>Prior to 1890, see Braastad; includes Marquette after 1892.

<sup>5</sup>Included in Cleveland Cliffs Group.

## MINERAL RESOURCES OF MICHIGAN.

## IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS)

	1904 and prior years.	1905.	1906.	1907.	1908.	1909.
(Austin).....				195,950	111,229	125,858
(Princeton) (Swanzy or Chesire).....	718,368	129,079	166,894	177,863	36,033	42,934
Stegmiller.....				6,305	52,588	39,869
(Stephenson).....						64,075
Total.....	718,368	129,079	166,894	380,118	199,850	272,736

## IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1904 and prior years.	1905.	1906.	1907.
Ada (included in Ironton).....				
Anvil.....	461,302	82,118	79,493	39,495
Ashland.....	3,818,905	409,131	341,841	298,056
Asteroid.....				
Aurora (Norrie-Aurora Group after 1904).....	3,961,684			
Bessemer.....	20,889			
Blue Jacket.....	1,799			
Brotherton.....	1,163,776	137,351	147,281	104,224
Castile.....			2,108	6,157
Chicago.....	68,727			
Colby.....	1,930,731	83,736	113,001	94,480
Davis (Wisconsin).....	100,801	3,160		
Eureka.....	128,719		37,525	57,904
Federal.....	36,443			
First National.....	1,997			
Geneva.....	7,108			
Imperial (see Federal).....				
Iron Chief.....	12,199			
Iron Chief No. 2.....	551			
Iron King (see Newport).....				
Ironton.....	140,919	41,314	106,158	190,968
Jack Pot.....	99,090			
Meteor (Comet).....	216,367			
Mikado.....	352,599	140,740	154,043	163,891
New Davis (see Davis).....				
Newport and Bonnie.....	2,718,031	438,023	549,745	551,496
Norrie-Aurora Group (after 1904)....	12,112,151	1,527,128	1,245,997	1,109,085
Pabst (Norrie-Aurora Group).....	2,366,583			
Palms.....	1,264,914	13,953	5,622	
Pike.....	16,238	11,161	17,934	24,922
Puritan (Ruby).....	109,572			
Royal.....				
Section 13.....				
Sparta.....	4,862			
Sunday Lake.....	834,146	79,209	86,879	101,899
Tilden.....	4,152,648	188,104	169,697	312,496
Vaughn (see Aurora) (Norrie-Au- rora Group after 1904).....				
Wakefield.....				
Wisconsin (see Davis).....				
Yale (West Colby).....	131,950	60,224	56,657	38,010
Total.....	36,235,701	3,215,352	3,113,981	3,093,083

STATISTICAL TABLES—IRON ORE.

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IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS.)

	1910.	1911.	1912.	1913.	Total.
(Austin) .....	188,588	110,839	102,530	107,365	942,359
(Princeton) (Swanzy or Chesire) ..	89,441	54,442	143,519	53,470	1,612,052
Stegmiller .....	48,842	45,122	50,963	45,431	230,227
(Stephenson) .....	225,726	135,474	214,386	96,298	794,852
Total .....	552,597	345,877	511,398	302,573	3,579,490

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

(Concluded.)

1908.	1909.	1910.	1911.	1912.	1913.	Totals.
35,937	22,927	7,235	310	55,610	238	784,665
259,611	259,612	231,506	151,478	211,927	2,635	5,984,702
			20,569	70,239	42,419	133,227
						3,961,684
						20,889
						1,799
96,776	103,090	102,626	65,015	148,930	70,138	2,139,207
	26,982	20,197	23,597	136,703	57,595	273,339
						68,727
58,305	170,095	194,754	41,673	245,195	306,744	3,237,714
						103,961
122,324	115,662	41,611	98,609	65,723	14,562	682,639
						364,443
						1,997
					31,303	38,411
						12,199
						551
92,932	277,594	109,025	63,359	173,135	166,123	1,361,527
						99,090
						216,367
86,617	99,195	52,715			33,111	1,082,911
579,390	1,008,354	1,182,324	555,853	966,435	1,139,666	9,689,317
773,243	977,054	1,333,006	883,910	1,500,758	1,503,451	22,965,783
				39,152	88,644	2,366,583
6,303	22,174	3,324				1,412,285
		50,019		90,683	64,463	102,056
						314,737
					10,659	10,659
					3,844	3,844
111,130	93,712	115,486	56,096	155,485	110,374	4,862
111,184	154,506	99,937	138,387	158,191	97,686	1,744,416
						5,582,836
					15,261	15,261
14,874	71,458	108,253	154,944	76,772	89,482	802,624
2,348,626	3,402,415	3,652,918	2,253,800	4,094,938	3,836,739	65,246,653

## MINERAL RESOURCES OF MICHIGAN.

## IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1904 and prior years.	1905.	1906.	1907.
Antoine.....	918,546	138,395	195,855	100,996
Aragon.....	4,066,607	423,698	431,000	441,636
Breen.....	17,430	16,625	21,004	20,366
Briar Hill.....	14,981			
Chapin.....	12,501,788	902,628	943,425	855,308
Clifford & Traders.....				
Cornell.....	49,302			
Cuff.....	58,419			
Cundy.....	807,967			
Curry.....	416,928			
Cyclops.....	286,093			
Eleanor (Appleton).....	12,102	1,819	3,121	1,677
Emmett.....	66,655			
Forest.....	11,988			
Half and Half.....	7,524			
Hamilton.....	96,072			
Hersel.....	955			
Indiana.....	17,871			
Keel Ridge.....	93,101			
Loretto.....	726,146	118,738	140,390	99,779
Ludington.....	1,001,518			
Millie (Hewitt).....	298,550		36,815	18,691
Munro.....	41,071	92,183	47,454	46,834
Norway.....	1,291,352			
Penn Iron Mining Co.....	2,932,179	423,244	496,582	381,128
Perry.....	3,138			
Pewabec.....	4,601,846	533,413	493,891	457,796
Quinnesec.....	499,756			
Saginaw (Perkins).....	396,225		21,017	26,080
Stephenson.....	39,350			
Sturgeon River.....	19,404			
Verona.....	130,975			
Vivian.....	133,860	90,426	122,577	48,493
Vulcan (with Penn Mines).....	1,668,654			
Walpole.....	19,089			
<b>Total.....</b>	<b>33,277,402</b>	<b>2,741,169</b>	<b>2,953,131</b>	<b>2,498,784</b>
<b>METROPOLITAN TROUGH.</b>				
Groveland.....	26,123			13,913
Metropolitan.....	107,027			
Northwestern.....	35,810			
<b>Total.....</b>	<b>168,960</b>			<b>13,913</b>
<b>CALUMET TROUGH.</b>				
Calumet.....	38,713		15,773	51,646

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

1908.	1909.	1910.	1911.	1912.	1913	Total.
						1,353,792
226,354	246,984	241,046	201,269	244,812	230,958	6,754,364
						75,425
						14,981
391,620	587,647	465,543	357,598	327,999	369,822	17,703,378
	103,626	91,081	90,940	74,144	95,311	455,102
						49,302
						58,419
1,410	5,512					844,889
						416,928
						286,093
						18,719
						66,655
						11,988
						7,524
						96,072
						955
						17,871
						93,101
13,354	96,613	116,048	18,579	135,177	158,257	1,623,081
						1,001,518
3,322	10,887		18,556			386,821
27,773	23,241	20,022	9,303	20,100	18,509	346,490
						1,291,352
176,211	428,004	344,760	377,026	426,743	416,410	6,402,287
						3,138
365,341	465,453	380,376	352,598	279,771	364,176	8,294,621
	3,147	744				503,647
38,669	19,994					501,985
						39,350
						19,404
						130,975
10,056		14,827	5,971	28,800	27,177	482,187
						1,668,654
						19,089
1,254,110	1,991,108	1,674,447	1,431,840	1,537,546	1,680,620	51,040,157
9,123	24,933	26,462	33,758	12,468	9,251	156,031
						107,027
						35,810
9,123	24,933	26,462	33,758	12,468	9,251	298,868
15,222				35,587	18,976	175,917



## IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1904 and prior years.	1905.	1906.	1907.
Alpha.....	1,370			
Armenia.....	247,061		27,882	36,665
Bristol (Claire).....	744,147	210,388	298,031	345,676
Columbia.....	914,820	27,883		
Crystal Falls.....	1,355,685	152,255	111,871	114,158
Delphic.....	33,770			
Dunn.....	1,065,127	21,051	91,476	141,992
Fairbanks.....	8,500			
Genesee (Ethel).....	208,529	77,370	80,971	38,984
Gibson.....	16,357			
Great Western.....	898,261	191,265	311,218	234,492
Hemlock.....	1,045,435	124,450	106,437	117,181
Hilltop.....	12,409		7,820	
Hollister.....	4,098			6,371
Hope.....	28,530			
Kimball.....				16,224
Lamont (Monitor).....	348,280	74,991	89,980	42,090
Lee Peck.....	2,844			
Lincoln.....	213,827	19,539	5,890	714
Magnate.....	6,844			
Mansfield.....	717,536	38,584		183,532
Mastodon.....	425,708			
McDonald.....				
Michigan.....	55,131	58,088	146	39,819
Monongahela.....	9,310			
Paint River (Fairbanks).....	255,190	11,973	28,321	75,805
Ravenna.....				
Sheldon & Shafer (Union) (see Col- umbia).....				
South Mastodon.....	8,203			
Tobin.....	233,250	166,529	235,867	237,781
Youngstown.....	151,425			
Total.....	9,011,647	1,174,366	1,395,910	1,631,484

STATISTICAL TABLES—IRON ORE.

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IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

(Concluded.)

1908.	1909.	1910.	1911.	1912.	1913.	Totals.
						1,370
		65,473	51,862	150,808	83,202	662,953
190,300	396,825	270,742	322,729	438,900	379,169	3,596,907
						942,703
296	986					1,735,251
						33,770
8,829	193,396	136,144	232,092	242,304	61,080	2,193,491
						8,500
	65,585	66,185	25,342	4,248		567,214
4,548	36,246	45,202	56,528			158,881
						2,091,061
124,246	112,747	80,709	84,338	3,342	50,464	2,052,311
83,834	112,481	115,407	107,753	126,132	113,201	20,229
						126,689
10,671	25,842	49,434	5,022		25,251	28,530
						16,224
		3,183				558,524
						2,844
	1,657					241,627
						6,844
44,633	118,713	114,357	54,646		190,503	1,462,504
						425,708
	1,114	6,022	5,240	1,384	16,499	30,259
603		17,922			27,917	199,636
						9,310
						371,289
			127	18,303	70,766	89,196
						8,203
161,642	359,668	235,812	308,456	319,318	154,896	2,413,219
						151,425
629,602	1,425,261	1,206,592	1,254,135	1,304,739	1,172,948	20,206,692

## MINERAL RESOURCES OF MICHIGAN.

## IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

	1904 and prior years.	1905.	1906.	1907.
Baker .....				
Baltic .....	356,340	133,246	186,495	189,119
Bengal .....				
Berkshire .....				
Beta .....	4,211			
Caspian .....	6,330	10,248	80,875	138,867
Cortland .....				14,883
Chatham-Riverton .....				
Davidson No. 1 .....				
Davidson No. 2 .....				
Chicagon .....				
Fogarty .....				7,949
Forbes .....				
Hiawatha .....	200,959	9,704	20	
Iron River .....	904,587			
James (Osana) .....				2,360
*Dober-Isabella .....	65,192			
Nanaimo .....	136,652	91,238	91,792	53,778
Riverton .....	588,152	82,611	161,704	90,358
Selden .....	2,092			
Sheridan .....	116,299			
Tully .....				
Virgil .....				
Wauseca .....				
Wickwire .....				
Youngs .....		10,926	47,583	92,632
Zimmerman .....				
Total .....	2,380,814	337,973	568,469	589,946

\*Riverton.

STATISTICAL TABLES—IRON ORE.

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IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.  
(Concluded.)

1908.	1909.	1910.	1911.	1912.	1913.	Totals.
	45,003	39,417	3,290		24,286	111,996
129,037	174,426	171,930	66,502	100,736	130,631	1,638,462
3,440	34,295	97,999	22,272	33,422	23,259	23,259
						191,428
						4,211
102,628	189,023	171,334	165,660	306,914	295,841	1,467,720
				17,499	26,823	44,322
45,826	68,730	51,988	58,054	135,298	107,604	482,383
			215	27,614	115,499	143,328
			45,219	98,760	79,948	223,927
			108,947	149,619	137,002	395,568
32,560	77,356	51,071	67,616	84,074	124,568	445,194
138,190	136,739	128,884	116,633	220,106	69,435	69,435
					160,511	1,111,746
						904,587
59,760	90,851	78,388	50,439	75,702	176,634	534,134
						65,192
805						373,765
47,073	171,200	84,269	200,142	171,493	160,818	1,757,820
						2,092
						116,299
		2,726	8,323		16,650	27,699
			749	3,750	48,395	52,145
			1,919	40,417	12,377	13,126
70,094	154,150	98,399	89,450	83,528	40,322	82,658
1,832	10,303	25,555	110,084	187,584	43,649	690,411
					149,309	484,667
630,745	1,152,076	1,001,960	1,115,514	1,736,516	1,943,560	11,457,573

## SUMMARY OF IRON ORE SHIPMENTS FROM MICHIGAN RANGES. (GROSS TONS.)

	1900 and prior years.	1901.	1902.	1903.	1904.
Marquette.....	59,190,552	3,178,295	3,749,977	2,956,022	2,767,242
Gwinn.....	373,585	67,051	118,048	84,223	76,461
Menominee.....	23,373,364	2,660,030	3,001,189	2,528,819	1,712,800
Crystal Falls.....	5,568,596	696,844	1,003,785	824,461	917,969
Iron River.....	1,306,655	157,541	355,110	276,785	284,273
Gogebic.....	26,653,146	2,419,144	3,018,255	2,465,263	2,042,398
Metropolitan.....	125,382	11,444	8,923	18,574	4,737
Calumet.....	38,913				
Total.....	116,630,093	9,190,349	11,255,287	9,154,147	7,805,880
	1905.	1906.	1907.	1908.	1909.
Marquette.....	4,086,493	3,935,293	3,907,955	2,214,782	3,988,436
Gwinn.....	129,079	166,894	380,118	199,850	272,736
Menominee.....	2,741,169	2,953,131	2,498,784	1,254,110	1,991,108
Crystal Falls.....	1,174,366	1,395,910	1,631,484	629,602	1,425,261
Iron River.....	337,973	568,469	589,946	630,745	1,152,076
Gogebic.....	3,215,352	3,113,981	3,093,083	2,348,626	3,402,415
Metropolitan.....			13,913	9,123	24,933
Calumet.....		15,773	51,646	15,222	
Total.....	11,684,432	12,149,451	12,166,929	7,302,060	12,251,965
	1910.	1911.	1912.	1913.	Total.
Marquette.....	3,840,129	2,614,881	3,406,646	3,487,993	103,319,696
Gwinn.....	552,597	345,877	510,398	302,573	3,579,490
Menominee.....	1,674,447	1,431,840	1,538,746	1,680,620	51,040,157
Crystal Falls.....	1,206,592	1,254,135	1,304,739	1,172,948	20,206,692
Iron River.....	1,001,960	1,115,514	1,736,966	1,943,560	11,457,573
Gogebic.....	3,652,918	2,102,322	3,883,011	3,836,739	65,246,653
Metropolitan.....	26,462	33,758	12,468	9,251	298,868
Calumet.....			35,387	18,976	175,917
Totals.....	11,955,105	8,898,327	12,428,361	12,452,660	255,325,046

SHIPMENTS OF IRON ORE FROM MICHIGAN RANGES BY COUNTIES.  
(GROSS TONS).

County.	1900 and prior years.	1901.	1902.	1903.	1904.
Gogebic.....	26,653,146	2,419,144	3,018,255	2,465,263	2,042,398
Iron.....	6,875,251	854,385	1,358,895	1,101,246	1,202,242
Dickinson.....	23,537,559	2,671,474	3,010,112	2,547,393	1,717,537
Marquette.....	59,017,911	3,241,008	3,808,244	2,905,597	2,817,195
Baraga.....	546,226	4,338	59,781	134,648	26,508
Total.....	116,630,093	9,190,349	11,255,287	9,154,147	7,805,880
County.	1905.	1906.	1907.	1908.	1909.
Gogebic.....	3,215,352	3,113,981	3,093,083	2,348,626	3,402,415
Iron.....	1,512,339	1,964,379	2,221,430	1,260,347	2,577,337
Dickinson.....	2,741,169	2,968,904	2,564,343	1,278,455	2,016,041
Marquette.....	4,175,605	4,097,111	4,154,288	2,305,366	3,888,055
Baraga.....	39,967	5,076	133,785	109,266	368,117
Total.....	11,684,432	12,149,451	12,166,929	7,302,060	12,251,965
County.	1910.	1911.	1912.	1913.	Totals.
Gogebic.....	3,652,918	2,102,322	3,883,011	3,836,739	65,246,653
Iron.....	2,208,552	2,369,649	3,041,705	3,116,508	31,664,265
Dickinson.....	1,700,909	1,465,598	1,585,601	1,708,847	51,514,942
Marquette.....	4,236,311	2,871,116	3,864,101	3,753,023	105,096,388
Baraga.....	156,415	89,642	53,943	37,543	1,802,798
Totals.....	11,955,105	8,898,327	12,428,361	12,452,660	255,325,046

## MINERAL RESOURCES OF MICHIGAN.

## LIST OF THE ACTIVE IRON MINES OF MICHIGAN.

Name of mine.	Location.				First ship- ment.	No. of men employed.	Depth 1913.
	County.	Section.	Twp.	Rge.			
<b>CRYSTAL FALLS DISTRICT:</b>							
Tobin .....	Iron .....	30	43	32	1901	231	1,235
Armenia .....	Iron .....	23	43	32	1889	102	690
Bristol .....	Iron .....	19	43	32	1892	248	1,060
Dunn-Richards .....	Iron .....	1	42	33	1887	220	1,512
Genesee (with Tobin) .....	Iron .....	29,30,31	43	32	1902	.....	.....
Great Western .....	Iron .....	21	43	32	1882	66	1,257
Gibson .....	Iron .....	15	44	33	1885	.....	.....
Hemlock .....	Iron .....	4	44	33	1891	139	1,015
Hollister .....	Iron .....	13	43	33	1890	17	600
Mansfield .....	Iron .....	17, 20	43	31	1890	40	1,450
McDonald .....	Iron .....	23	43	32	1909	50	417
Michigan (with Hemlock) .....	Iron .....	9	44	33	1893	.....	611
Ravenna .....	Iron .....	19	43	32	1911	147	250
<b>IRON RIVER DISTRICT:</b>							
Tully (see Baker) .....	Iron .....	36	43	35	1910	.....	548
Baker—Tully .....	Iron .....	31	43	34	1909	272	548
Baltic .....	Iron .....	7	42	34	1901	315	553
Bengal .....	Iron .....	36	43	35	1913	70	281
Berkshire .....	Iron .....	6	42	34	1908	100	365
Caspian .....	Iron .....	1	42	35	1903	329	292
Chatham—Riverton .....	Iron .....	35	43	35	1907	125	700
Chicago .....	Iron .....	26	43	34	1911	113	510
Cortland .....	Iron .....	34	43	35	1912	39	405
Davidson No. 1 .....	Iron .....	23	43	35	1912	127	450
Davidson No. 2 .....	Iron .....	14	43	35	1912	106	240
Fogarty (see Baltic) .....	Iron .....	1	42	35	1907	.....	365
Forbes .....	Iron .....	14	43	35	1913	142	275
Hiawatha .....	Iron .....	35	43	35	1893	102	857
Osana .....	Iron .....	23	43	35	1907	151	428
Dober Isabella .....	Iron .....	1, 35, 36	42, 43	35	1896	200	802
Virgil .....	Iron .....	24	43	35	1912	67	273
Wauseca .....	Iron .....	23	43	35	1910	36	398
Wickwire .....	Iron .....	35	43	35	1911	64	213
Youngs .....	Iron .....	12	42	35	1905	50	515
Zimmerman .....	Iron .....	7	42	34	1908	167	350
<b>GOGEBIC RANGE:</b>							
Anvil .....	Gogebic .....	14	47	46	1887	234	1,663
Asteroid .....	Gogebic .....	13	47	46	1906	116	1,035
Ashland .....	Gogebic .....	22	47	47	1885	120	1,850
Brotherton .....	Gogebic .....	9	47	45	1886	146	1,157
Castile .....	Gogebic .....	10	47	45	1906	146	1,470
Colby .....	Gogebic .....	16	47	46	1884	645	1,289
Davis, Geneva, Royal, Puritan .....	Gogebic .....	17, 18, 19, 20	46	47	1886	248	1,754
Eureka .....	Gogebic .....	13	47	46	1890	73	1,500
Ironton (See Colby) .....	Gogebic .....	17	47	46	1886	.....	1,350
Mikado .....	Gogebic .....	18	47	45	1895	59	1,131
Newport and Bonnie .....	Gogebic .....	24	47	47	1886	1,507	2,154
Norrie-Aurora Group .....	Gogebic .....	22, 23	47	47	1884	1,791	1,676 <sup>1</sup>
Palms (see Anvil) .....	Gogebic .....	14	47	46	1912	.....	1,663
Puritan (see Davis) .....	Gogebic .....	17	47	46	1886	.....	.....
Sunday Lake .....	Gogebic .....	10	47	45	1885	213	1,263
Tilden .....	Gogebic .....	15	47	46	1891	271	1,326
Wakefield .....	Gogebic .....	16, 17	47	45	1913	127	82
Yale .....	Gogebic .....	16	47	46	1901	122	861

<sup>(1)</sup> Depth of North Norrie.

STATISTICAL TABLES—IRON ORE.

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1913, WITH LOCATION, OWNERSHIP, ETC.

Number or name of level.	Operators.	Address of Home Office.
12th	Corrigan, McKinney Co.	Wickliffe, Ohio.
9th	Corrigan, McKinney Co.	Wickliffe, Ohio.
11th	Bristol Mining Co.	Wade Building, Cleveland, Ohio.
12th	Corrigan, McKinney Co.	Wickliffe, Ohio.
.....	Corrigan, McKinney Co.	Wickliffe, Ohio.
16th	Corrigan, McKinney Co.	Wickliffe, Ohio.
.....	Rogers Brown Ore Co.	1515 Corn Exchange Bank Bldg., Chicago, Ill.
14th	Hemlock River Mining Co.	Cleveland, Ohio.
.....	Hollister Mining Co.	1300 Leader-News Bldg., Cleveland, Ohio.
17th	Oliver Iron Mining Co.	Duluth Minn., Wolvin Bldg.
4th	McDonald Mining Co.	Cleveland, Ohio.
.....	Hemlock River Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
1st	Hollister Mining Co.	1300 Leader News Bldg., Cleveland, Ohio.
.....	Corrigan, McKinney Co.	Wickliffe, Ohio.
.....	Corrigan, McKinney Co.	Wickliffe, Ohio.
7th	Verona Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
2d	Verona Mining Co.	Cleveland Ohio, Western Reserve Bldg.
4th	Brule Mining Co.	Wade Building, Cleveland, Ohio.
3d	Verona Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
7th	Brule Mining Co.	Wade Bldg., Cleveland, Ohio.
5th	Munro Mining Co.	55 Erie Co. Bank Bldg., Buffalo, N. Y.
4th	Wickwire Mining Co.	Buffalo, N. Y.
1st	Davidson Ore Mining Co.	403 White Bldg., Buffalo, N. Y.
2d	Davidson Ore Mining Co.	403 White Bldg., Buffalo, N. Y.
4th	Verona Mining Co.	Western Reserve Bldg., Cleveland, Ohio.
2d	Jones & Laughlin Ore Co.	3d Ave. & Try St., Pittsburg, Pa.
8th	Munro Mining Co.	55 Erie Co. Bank Bldg., Buffalo, N. Y.
4th	Mineral Mining Co.	910 Wells Bldg., Milwaukee, Wis.
8th	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
2d	Wickwire Mining Co.	Buffalo, N. Y.
4th	Mineral Mining Co.	910 Wells Bldg., Milwaukee, Wis.
3d	Huron Iron Co.	Iron River, Mich.
5th	Wickwire Mining Co.	Buffalo, N. Y.
4th	Spring Valley Iron Co.	Wellston, Ohio., Jackson Co.
11th	Newport Mining Co.	Colby Abbot Bldg., Milwaukee, Wis.
11th	Castile Mining Co.	76 Wade Bldg., Cleveland, Ohio.
24th	Hayes Mining Co.	808 1st National Bank Bldg., San Jose, Cal.
21st	Brotherton Iron Mining Co.	Western Reserve Bldg., Cleveland, Ohio.
14th	Castile Mining Co.	76 Wade Bldg., Cleveland, Ohio.
14th	Corrigan, McKinney Co.	Wickliffe, Ohio.
18th	Oliver Iron Mining Co.	Wolvin, Bldg., Duluth, Minn.
15th	Castile Mining Co.	76 Wade Bldg., Cleveland, Ohio.
.....	Corrigan, McKinney Co.	Wickliffe, Ohio.
16th	Verona Mining Co.	Western Reserve Bldg., Cleveland, Ohio.
19th	Newport Mining Co.	Colby Abbot Bldg., Milwaukee, Wis.
23d	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
11th	Dunn Iron Mining Co.	Colby Abbot Bldg., Milwaukee, Wis.
.....	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
22d	Sunday Lake Iron Co.	Western Reserve Bldg., Cleveland, Ohio.
21st	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
Open pit	Wakefield Iron Co.	1300 Leader-News Bldg., Cleveland, Ohio.
10th	Lake Superior Iron & Chemical Co.	Penobscot Bldg., Detroit, Mich.



## LIST OF THE ACTIVE IRON MINES OF MICHIGAN.

Name of mine.	Location.				First ship- ment.	No. of men employed.	Depth 1913. Feet.
	County.	Sec.	T'p.	Rge.			
<b>MARQUETTE RANGE:</b>							
American and Boston . . . . .	Marquette . . . . .	32	48	28	1880	321	1,460
Breitung Hematite No. 1 . . . . .	Marquette . . . . .	8	47	26	1903	111	585
Breitung Hematite No. 2 . . . . .	Marquette . . . . .	8	47	26	.....	80	435
Cambria . . . . .	Marquette . . . . .	35	48	27	1875	157	978
Champion . . . . .	Marquette . . . . .	31, 32	48	29	1867	4	1,984
Chase . . . . .	Marquette . . . . .	3	47	28	1913	67	250
Cliff Shaft . . . . .	Marquette . . . . .	9, 10	47	27	1887	268	987
Empire . . . . .	Marquette . . . . .	19	47	26	1907	16	200
Hartford (Cambria No. 2) . . . . .	Marquette . . . . .	36	48	27	1889	.....	1,075
Imperial . . . . .	Baraga . . . . .	25	48	31	1890	6	185
Jackson . . . . .	Marquette . . . . .	1	47	27	1846	24	208
Lake and Moro . . . . .	Marquette . . . . .	10	47	27	1892	351	591
Lake Superior (Hard Ore) . . . . .	Marquette . . . . .	9, 10	47	27	1858	270	1,080
Lake Superior, (Soft Ore) . . . . .	Marquette . . . . .	10	47	27	1858	68	820
Lake Angeline . . . . .	Marquette . . . . .	15	47	27	1864	265	615
Lloyd (see Morris) . . . . .	Marquette . . . . .	6	47	27	1911	.....	808
Lucy (with Jackson) . . . . .	Marquette . . . . .	6, 7	47	26	1878	.....	281
Maas . . . . .	Marquette . . . . .	31	48	26	1907	266	1,100
Mitchell . . . . .	Marquette . . . . .	21	47	27	1886	22	768
Maitland (Volunteer) . . . . .	Marquette . . . . .	30	47	26	.....	.....	.....
Mary Charlotte . . . . .	Marquette . . . . .	8	47	26	1903	300	435
Morris and Lloyd . . . . .	Marquette . . . . .	1	47	28	1912	182	798
Milwaukee-Davis . . . . .	Marquette . . . . .	7	47	26	1879	44	525
Moro (with Lake) . . . . .	Marquette . . . . .	10	47	27	1881	.....	812
Negaunee . . . . .	Marquette . . . . .	5, 6	47	26	1887	353	986
Ohio . . . . .	Baraga . . . . .	22	48	31	1882	7	250
Portland . . . . .	Baraga . . . . .	26	48	31	1896	None	50
Queen . . . . .	Marquette . . . . .	5	47	26	1888	289	1,010
Republic . . . . .	Marquette . . . . .	7	46	29	1872	410	2,050
Richmond . . . . .	Marquette . . . . .	28	47	26	1896	50	.....
Rolling Mill . . . . .	Marquette . . . . .	7	47	26	1872	235	700
Salisbury . . . . .	Marquette . . . . .	15	47	27	1872	148	709
Volunteer . . . . .	Marquette . . . . .	30	47	26	1871	144	505
Washington (Barron) . . . . .	Marquette . . . . .	11	47	29	1865	81	875
<b>SWANZY DISTRICT:</b>							
Austin . . . . .	Marquette . . . . .	20	45	25	1907	63	364
Princeton . . . . .	Marquette . . . . .	18, 20	45	25	1872	80	782
Stegmiller . . . . .	Marquette . . . . .	17	45	25	1909	64	300
Stephenson . . . . .	Marquette . . . . .	20	45	25	1907	290	500
<b>MENOMINEE RANGE:</b>							
Aragon . . . . .	Dickinson . . . . .	8, 9	39	29	1889	297	1,155
Chapin . . . . .	Dickinson . . . . .	25, 30	40	31, 30	1880	632	1,501
Cyclops & Norway (Penn Gr'p) . . . . .	Dickinson . . . . .	5	39	29	1878	.....	355
East Vulcan (Penn Group) . . . . .	Dickinson . . . . .	10, 11	39	29	1877	.....	1,400
Loretto . . . . .	Dickinson . . . . .	7	39	28	1893	212	800
Millie (Hewitt) . . . . .	Dickinson . . . . .	31	40	34	1881	Idle	600
Munro . . . . .	Dickinson . . . . .	6	39	29	1903	29	170
Pewabic . . . . .	Dickinson . . . . .	32	40	30	1890	380	941
Quinnesec . . . . .	Dickinson . . . . .	34	40	30	1878	Idle	450
Vivian . . . . .	Dickinson . . . . .	34	40	30	1902	15	310
West Vulcan, Curry & Brier Hill . . . . .	Dickinson . . . . .	9, 10	39	29	1879	776 <sup>1</sup>	1,770
Clifford and Traders . . . . .	Dickinson . . . . .	20	40	30	.....	56	143
<b>METROPOLITAN TROUGH:</b>							
Groveland . . . . .	Dickinson . . . . .	31	42	29	1891	.....	200
<b>CALUMET TROUGH:</b>							
Calumet . . . . .	Dickinson . . . . .	8	41	23	1882	2	206

<sup>1</sup>Total for Penn Group.

STATISTICAL TABLES—IRON ORE.

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1913, WITH LOCATION, OWNERSHIP, ETC.

Number or name of level.	Operators.	Address of Home Office.
18th	American Boston Mining Co. ....	1300 Leader-News Building, Cleveland, Ohio.
9th	Breitung Hematite Mng. Co. ....	Marquette, Mich.
4th	Breitung Hematite Mng. Co. ....	Marquette, Mich.
5th	Republic Iron & Steel Co. ....	Youngstown, Ohio.
33d	Champion Iron Co. ....	Wolvin Building, Duluth, Minnesota.
2d	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
10th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
2d	Empire Iron Co. ....	Rector Building, Chicago, Illinois.
.....	Republic Iron & Steel Co. ....	Youngstown, Ohio.
4th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
.....	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
5th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
.....	Oliver Iron Mining Co. ....	Wolvin Building, Duluth, Minn.
.....	Oliver Iron Mining Co. ....	Wolvin Building, Duluth, Minn.
9th	Pittsburg & Lake Angeline Iron Co. ....	Cleveland, Ohio.
2d	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
.....	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
3d	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
.....	Pittsburg & Lake Angeline Iron Co. ....	Cleveland, Ohio.
.....	Volunteer Ore Co. ....	1400 Alworth Bld, Duluth, Minn.
4th	Mary Charlotte Mining Co. ....	Marquette, Mich.
2d	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
.....	Mary Charlotte Mining Co. ....	Marquette, Mich.
.....	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
9th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
6th	Niagara Iron Mining Co. ....	North Tonawanda, N. Y.
Open pit	Niagara Iron Mining Co. ....	North Tonawanda, N. Y.
"Pasco"	Oliver Iron Mining Co. ....	Wolvin Bldg., Duluth, Minn.
Open pit	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
.....	Richmond Iron Co. ....	1300 Leader-News Bldg., Cleveland, Ohio.
7th	Jones & Laughlin Ore Co. ....	3d Ave. & Try St., Pittsburg, Pa.
16th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
5th	Volunteer Ore Co. ....	1400 Alworth Bldg., Duluth, Minn.
10th	Washington Iron Co. ....	Marquette, Mich.
6th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
6th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
2d	American Mining Co. ....	Western Reserve Building, Cleveland, Ohio.
5th	Cleveland Cliffs Iron Co. ....	Ishpeming, Mich.
12th	National Tube Works Co. ....	Frick Bldg., Pittsburg, Pa.
17th	Chapin Mining Co. ....	Wolvin Bldg., Duluth, Minn.
.....	Penn Iron Mining Co. ....	1703 Morris Bldg., Philadelphia, Pa.
.....	Penn Iron Mining Co. ....	1703 Morris Bldg., Philadelphia, Pa.
8th	Loretto Iron Co. ....	1400 Fulton St., Chicago, Ill.
.....	Dessau Mining Co. ....	Care B. J. Clergue, Montreal, Que.
2d	Munro Iron Mining Co. ....	55 Erie Co. Bank Bldg., Buffalo, N. Y.
8th	Pewabic Co. ....	910 Wells Bldg., Milwaukee, Wisconsin.
.....	Corrigan, McKinney Co. ....	Wickliffe, Ohio.
.....	Verona Mining Co. ....	Western Reserve Bldg., Cleveland, Ohio.
18th	Penn Iron Mining Co. ....	1703 Morris Bldg., Philadelphia, Pa.
1st	Antoine Ore Company. ....	Republic Bldg., Youngstown, Ohio.
.....	Groveland Mining Co. ....	Trustee, J. S. Courtney, Marquette, Mich.
2d	Calumet Ore Co. ....	Western Reserve Bldg., Cleveland, Ohio.



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**PART II.**  
**NONMETALLIC MINERALS.**

**BY**

**R. A. SMITH.**

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## LIMESTONE.

A study of the following table shows that the limestone industry in Michigan has made an almost uninterrupted growth from 1899 to the present time, the total value increasing from about \$282,000 in 1899 to \$1,408,708 in 1913. Twenty-five quarries were in operation in 1913, located chiefly in Monroe, Charlevoix, Emmet, Alpena, Presque Isle, Schoolcraft and Mackinac counties. Other quarries are located near Menominee, Escanaba, Omer (Arenac county), Bellevue (Eaton county), Bayport (Huron county), and at Sibley near Detroit. A number of quarries are idle but some will be reopened in 1914. New developments are in progress on the D. N. McLeod property in section 31, T. 45 N., R. 8 W. and section 36, T. 45 N., R. 9 W. in Luce county. Other important developments are contemplated or are in progress at Rockport, Alpena county, by the Great Lakes Stone & Lime Co.; near Mackinaw City, Cheboygan county, by the Cheboygan Limestone Products Co.; and near Charlevoix by the Wolverine Lime Co.

The principal limestone formations in Michigan are the Trenton of Ordovician age, the Niagara and the Monroe of the Silurian, the Dundee and Traverse of the Devonian, and the Bayport of the Mississippian. The Trenton consists chiefly of limestone and dolomite, grayish buff to blue in color. Toward the base, the formation is blue and shaly or solid shale. In the Northern Peninsula numerous outcrops of the Trenton limestone occur along the lower courses of the Menominee, Ford, and Escanaba rivers, and in the valley of Rapid and Whitefish rivers. The stone varies in composition from high calcium to high magnesia, but the amount of argillaceous and silicious material renders most of the stone unfit for lime burning or chemical purposes. The stone is quarried near Menominee and Escanaba for road metal and rough building block.

Extensive outcrops of the Niagara limestone occur throughout a broad belt extending from the southern part of Garden Peninsula, Delta county, along the northern shores of lakes Michigan and Huron to the eastern part of Drummond Island. The outcrops generally occur in prominent ridges with precipitous northern slopes and gentle southern ones and this affords most favorable conditions for quarrying. The formation is approximately 600 feet in thickness and consists of a great variety of limestones and dolomites. Some of the

limestones are very massive and others very thin bedded. Many of the beds in the middle portion of the formation are very fossiliferous and cherty. In composition, the beds range from high calcium limestone to normal dolomite and unlimited quantities of limestone suitable for almost every purpose may be found in the belt of Niagara limestone even within a radius of a few miles. Unfortunately in many cases, the valuable limestones are associated with cherty, "rotten," or low grade limestones unfit for any use, and the cost of removing these is prohibitive.

At or near the top of the Niagara, there is a massive bed of dolomite more than 50 feet in thickness. This bed is the cap-rock of the Niagara escarpment from Whitedale (Gulliver postoffice), Schoolcraft county, eastward to Point Detour, Chippewa county. The stone is a normal dolomite in composition, is free from clayey material and contains but little impurity other than chert or sand which is present in injurious amounts only locally. The stone, of which there is an inexhaustible supply, is said to be especially adapted to blast furnace or paper mill purposes. Mr. E. W. Hough has opened a quarry at Ozark in this bed.

In the lower part of the Niagara, there is a series of high calcium limestones interbedded with dolomites and dolomitic limestones. The most important high calcium bed is from 18 to 30 feet in thickness and consists of a massive very brittle lithographic limestone buff to buff gray in color. The lithographic texture and small disseminated crystals of calcite are characteristic of the bed. It has been traced from a point four miles north of Whitedale, Schoolcraft county, eastward through Blaney quarry, Gould City, Hendricks (Rex) and Fiborn quarries into the western part of Trout lake township, Chippewa county. Drift specimens were found near Pittsburg Landing and on Lime Island, St. Mary's river. This limestone is quarried on a large scale at Fiborn, Hendricks (Rex), and Blaney quarries for blast furnaces and sugar factories, and for road making.

When wood was abundant many small lime kilns were operated along St. Marys river, and the Duluth, South Shore and Atlantic and the "Soo" railroads. The difficulty of burning many of the Niagara limestones and dolomites and the exhaustion of suitable wood for fuel caused the early abandonment of most of these small kilns.

A middle portion of the Niagara consists of a large series of dense to crystalline light colored dolomitic limestones and dolomites, some of which are fossiliferous and cherty. Some of the dolomites and magnesian limestones make very good lime and have been developed on a considerable scale by the White Marble Lime Company at Manistique and Marblehead, Schoolcraft county. The stone in certain beds at

Manistique is unsuitable for lime burning, but most of it is hard and and tough and is crushed for road material.

The bluffs near Drummond, Drummond Island, consist chiefly of very massive, dense to fine grained dolomites which are divided into very large rectangular blocks by two systems of joint planes approximately at right angles. The hardness of the stone and the favorable quarrying conditions have led to the extensive quarrying of block stone near Drummond for use in the locks of the ship canals at the "Soo." At present the quarries are idle.

In conclusion it may be said that the Niagara formation contains an enormous amount and a great variety of commercial stone. There are unlimited supplies of magnesian stone suitable for blast furnace and paper mill purposes, and there are at least twenty sections of high calcium limestone favorably situated for quarrying operations and adapted for use in the manufacture of sugar, carbide and soda ash.

The Monroe formation outcrops in the St. Ignace Peninsula and in eastern Monroe county. The Upper Monroe in southeastern Michigan consists of dolomites and the intercalated high calcium Anderdon limestone. In general the dolomites are fit only for road metal, concrete material and building block. The Anderdon limestone is quarried at Sibley, Wayne county in connection with the overlying Dundee limestone and is used chiefly in the manufacture of soda ash. The Lower Monroe is essentially a dolomite formation and the stone has been quarried mainly for road metal, concrete and building block. In Monroe county and in the St. Ignace peninsula, a peculiar brecciation is locally characteristic of the Monroe dolomites and the stone is practically worthless for any use. Many small quarries were formerly operated in Monroe county, furnishing crushed and block stone to Detroit, but the great amount of limestone secured from dredging operations in Detroit river have forced most of these quarries out of business. The present quarries furnish crushed stone for the local markets and for road building.

In the northern part of the Southern Peninsula, the Dundee limestone outcrops near the lake shore four miles southeast of Mackinaw City, Cheboygan county, near Rogers City and Thompson's Harbor, Presque Isle county and on Middle Island, Lake Huron. In southeastern Michigan, the Dundee outcrops at Sibley, Wayne county and in the vicinity of Dundee, Monroe county. The Dundee is essentially a true limestone formation and contains much high calcium stone of great purity, some beds averaging 98 to 99 per cent calcium carbonate. Unfortunately the formation is generally deeply buried by glacial drift.

Large quarries are operated by the Michigan Limestone & Chemical



Co. at Calcite near Rogers City and by the Solvay Process Co. of Detroit at Sibley. A new quarry is being opened by the Cheboygan Limestone Products Co. about four miles southeast of Mackinaw City, and considerable drilling has been done in the vicinity of the Mary R. Bullock (formerly the Macon or Christiancy) quarry two miles northeast of Dundee on Macon river. The available stone in the old quarry back of the National Hotel in Dundee has been exhausted.

The Traverse formation consists of a series of shales and limestones, a heavy shale always being found at the base of the formation. Numerous outcrops of the Traverse, especially of the hard limestones, occur along the south shore of Little Traverse Bay and in Presque Isle and Alpena counties. In southeastern Michigan, it is deeply buried beneath glacial drift.

Some of the beds of limestone are locally very pure, containing 97 to over 99 per cent of calcium carbonate. The purest portions are in the vicinity of the coral reefs which characterize some of the limestone beds. Certain of the limestones contain a large amount of shaly material and gradations from shale into limestone and vice versa are characteristic of the Traverse formation.

The high calcium beds of the Traverse have been more extensively developed than the limestones of any other formation. The principal quarries are along the south side of Little Traverse bay near Charlevoix, Charlevoix county, Bay Shore and Petoskey, Emmet county; and near Alpena in Alpena county. Important quarries are also located near Afton, Cheboygan county. The quarry at Onaway has been idle for some time but new quarries are being opened at Rockport, Alpena county, by the Great Lakes Stone & Lime Co. and by the Wolverine Lime Co. near Charlevoix.

The high calcium stone of the Traverse is chiefly used in making Portland cement, soda ash, bleach, sugar, and chemical lime. The lower grade stone is crushed for concrete and road material, ground for agricultural purposes, or burned for commercial lime.

The Bayport limestone of the Grand Rapids series consists of light colored to bluish limestone, dolomite and sandstone. Some of the limestone is high calcium but the formation is locally very cherty and sandy, rendering the stone unfit for lime burning or for use in making soda ash, Portland cement, sugar, etc.

The formation has been heavily eroded and in Jackson county it forms the cap rock of some of the hills. At Bellevue, the Burt Portland Cement Co. operates a large quarry, utilizing the limestone and associated shale in the manufacture of Portland cement. At Bayport, Huron county, the Wallace Stone Co. have operated a quarry

for many years. Formerly the stone from an upper high calcium bed was used for lime but this bed is now exhausted. The lower beds in the quarry are hard, dolomitic and very silicious or sandy. The silicious material is largely present in the form of a cement, and this probably accounts for the exceptional hardness and toughness of the stone which make it especially adapted for road building.

In Arenac county, there are a number of outcrops of the Bayport limestone. Some of the stone is high calcium but it is cherty and requires more or less careful sorting. At the McDonnell quarry, three miles south of Twining, the stone is utilized chiefly for burning lime. The M. J. Griffin quarry two miles northeast of Omer has been idle for the past six years.

In brief it may be stated that Michigan has enormous supplies of limestone of almost every variety, but most of the available supplies are in the Northern Peninsula and in the northern part of the Southern Peninsula far from the manufacturing and commercial centers.

In 1913 Mr. R. A. Smith of the Geological Survey of Michigan made an investigation of the limestone resources of the Northern Peninsula. The work upon the limestones of the Southern Peninsula will be completed in 1914, and the results of the investigations are to be published in a report on the limestone resources of the state. This report will probably be available before the close of 1915.

VALUE OF THE PRODUCTION OF LIMESTONE IN MICHIGAN, 1899-1913.

Year.	Rough building. Value.	Dressed building. Value.	Paving. Value.	Curbing. Value.	Flagging. Value.	Rubble. Value.	Riprap. Value.	Crushed stone.		
								Road making. Value.	Railroad ballast. Value.	Concrete. Value.
1899.....	\$30,299	a	\$62,815				\$1,111			
1900.....	32,362	a	105,266				799 <sup>c</sup>	\$31,605	\$18,200	\$75,643
1901.....	47,785	a			\$380	\$5,098	5,740	56,261	40,810	49,430
1902.....	58,707	a		\$489	200	3,710	800	61,342	35,340	48,504
1903.....	36,528	a	49,000	250	5,150	2,800	2,405	58,655	57,100	60,745
1904.....	32,941	\$805	37,665			2,744	1,568	112,113	43,649	107,396
1905.....	17,071			160			1,204	78,437	103,442	87,762
1906.....	9,368	641	90,723	75		4,654	1,234	131,708	46,516	112,829
1907.....	15,120	100	56,500			1,433	1,574	182,510	33,900	73,200
1908.....	7,276		10,825	300	100	15,907	3,815	132,902	42,445	112,829
1909.....	4,450	7,445	35,500			1,572	380	110,184	42,358	178,318
1910.....	3,552					2,205	75	113,574	34,998	137,285
1911.....	7,526					165		295,449	28,368	97,298
1912.....	9,997					380	610	266,316	48,400	145,965
1913.....	8,274					3,511				
Total.....	\$321,256		\$448,294		\$5,730	\$42,280	\$22,023	\$1,631,056	\$575,526	\$1,246,227

a Included under rough building.

b Included under flagging.

c Included under rubble.

# NONMETALLIC MINERALS.

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VALUE OF THE PRODUCTION OF LIMESTONE IN MICHIGAN, 1890-1913.—Concluded.

Year.	Flux. Value.	Sugar factories. Value.	To chemical plants. Value.	To paper mills. Value.	For agricultural purposes. Value.	Sold to lime burners. Value.	Other. Value.	Total. Value.
1899.....	\$27,512	.....	.....	.....	.....	\$157,657	\$2,375	\$281,769
1900.....	3,200	.....	.....	.....	.....	65,000	124,220	330,847
1901.....	13,488	.....	.....	.....	.....	136,173	101,399	429,771
1902.....	32,246	.....	.....	.....	.....	98,000	68,164	413,148
1903.....	15,502	.....	.....	.....	.....	132,600	4,747	390,473
1904.....	62,586	.....	.....	.....	.....	180,683	5,323	501,708
1905.....	109,883	.....	.....	.....	.....	9,380	142,790	544,754
1906.....	81,517	\$224,356	.....	.....	.....	.....	.....	656,260
1907.....	109,429	22,234	.....	.....	.....	.....	378,297	760,333
1908.....	56,841	32,594	.....	.....	.....	.....	253,990	669,017
1909.....	91,915	25,845	.....	.....	.....	.....	327,571	750,589
1910.....	100,149	69,647	.....	.....	.....	.....	299,305	842,126
1911.....	186,046	65,141	.....	.....	.....	.....	440,857	1,005,751
1912.....	137,812	36,944	\$508,044 <sup>a</sup>	\$12,558	\$3,003	.....	13,596	1,139,560
1913.....	494,495	38,215	320,961	8,150	3,447	.....	64,190	1,408,703
Total.....	\$1,522,621	\$514,976	.....	\$31,431	\$13,498	\$779,493	\$2,148,200	\$10,124,818

<sup>a</sup> Included under other value.

## LIME.

The lime industry in Michigan has made but a relatively small growth in the last 10 years in comparison with the limestone industry. This is largely due to several factors, viz: (1) the growing scarcity of suitable wood for burning lime, (2) the introduction of the era of concrete, (3) the poor location of suitable limestones, and (4) the invention of gypsum plasters and other plaster substitutes. The supplies of cheap wood fuel are nearing exhaustion and much of the limestone suitable for making lime is used for other purposes or is located far from large markets. No lime is produced in the southern half of the Southern Peninsula. Concrete has largely replaced stone and lime mortar in construction work and gypsum plasters and plaster-board, sand-lime mortar for plastering. Most of the lime produced is of the "hot" variety, there being but little of the mild magnesian lime burned. The production of hydrated lime, produced by only two companies, shows a material increase. The use of lime as a fertilizer or soil rectifier has opened a new field for the disposal of the lime product.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1913.

Year.	Total lime burned.		Average price per ton.	No. of plants operating.	Rank of state. Production.
	Quantity, tons.	Value.			
1904.....	63,601	\$256,955	\$4 04		
1905.....	48,089	192,844	4 01		
1906.....	68,133	281,465	4 13	13	
1907.....	65,822	276,534	4 20	12	
1908.....	68,050	282,023	4 14	10	15
1909.....	83,108	354,135	4 26	12	13
1910.....	72,345	303,377	4 19	10	14
1911.....	80,709	352,608	4 37	14	14
1912.....	74,720	311,448	4 17	11	16
1913.....	77,088	331,852	4 05	10	14
Total.....	701,665	\$2,943,241			

## SANDSTONE.

The value of sandstone annually produced in Michigan has decreased from about \$188,000 in 1902 to less than \$13,000 in 1911, but the years of 1912 and 1913 show slight increases, the total value being \$19,220 in the latter year. The decline of the sandstone industry may be ascribed, (1) to the poor quality of most of the sandstone in Michigan, (2) to the substitution of concrete in construction work, and (3) to the greater use of brick and artificial stone.

Sandstones belonging to the Coal Measures were formerly quarried near Ionia, and quarries in the Marshall sandstone were operated in Jackson, Calhoun, Hillsdale, and Huron counties. Most of the sandstone from these formations, upon exposure to the weather for a few years, alters in spots or uniformly to an unsightly yellow color. Some of the sandstone at Ionia, though locally soft and friable, is streaked and mottled by various tones of yellow and red which give a pleasing appearance in structures. No quarries are now operating in the sandstones of the Coal Measures or of the Upper Marshall, but some rubble and riprap are produced in connection with the quarrying of grindstones from the Lower Marshall in Huron county. Most of the present output of sandstone is derived from the Lake Superior or "Eastern" sandstone, which is quarried extensively by the Portage Entry Quarries Co. and the Portage Entry Redstone Co. at Jacobsville, Houghton county. The "redstone" or "brownstone" of the "Eastern" is well cemented, permanent in color and has a pleasing appearance, but the great distance of the deposits of the better grades of "Eastern" sandstone from ready markets has been and will continue to be an effective obstacle in the way of their development.

## MINERAL RESOURCES OF MICHIGAN.

\*PRODUCTION AND VALUE OF SANDSTONE IN MICHIGAN, 1899-1913.

Year.	Rough building. Value.	Dressed building. Value.	Curbing. Value.	Flagging. Value.	Rubble. Value.	Riprap. Value.	Crushed stone.		Other. Value.	To al value.
							Road making. Value.	Concrete. Value.		
1899.	\$102,447	\$51,682	\$109	a					\$23,800	\$178,038
1900.	73,850	58,800			\$28,519					132,650
1901.	128,909				27,393	b			19,000	174,428
1902.	136,280	23,600			15,554	\$800				186,073
1903.	89,931	10,365			10,657		\$2,050	\$3,450		121,350
1904.	47,593	14,818			10,332		1,400	400		74,868
1905.	64,056	36,035			10,403				12,700	123,123
1906.	35,272	18,950			7,900	770				65,395
1907.	33,561	10,918		\$528	5,190	96				53,003
1908.	15,100	18,813			6,294					39,103
1909.	12,985	16,805			2,505					36,084
1910.	13,312	15,416			3,068					31,233
1911.	5,682	2,809			c	1,140			286	12,985
1912.	c	c			c	c			a	16,438
1913.	c	c			c	3,127			c	19,224
Totals.			\$109					\$3,850		\$1,265,995

a Included under curbing.

b Included under rubble.

c Included in total.

\* Exclusive of sandstone made into grindstones and whetstones.

## SHALE.

Shale is quarried in Michigan chiefly for use in making Portland cement and vitrified brick and tile. Near Coldwater and Alpena and in Charlevoix county, shale has been quarried at several places for use in the manufacture of Portland cement. At Grand Ledge and Jackson soft shales, so-called "fire clays" of the Coal Measures, are quarried or mined on a large scale in making vitrified sewer pipe, tile, conduit and stove lining. Vitrified brick are made from Coal Measure shales at Corunna, Shiawassee county, Frankenlust, Bay county and Flushing, Genesee county.

Excellent exposures of the Coldwater shale occur at Richmondville and along the shore of Lake Huron from Forestville to White Rock in Sanilac and Huron counties and numerous outcrops occur in the vicinity of Coldwater, Union City, Quincy and Bronson, Branch county.

A number of exposures of the Antrim shale occur in Charlevoix and Antrim counties near East Jordan, Norwood and Ellsworth, and a prominent exposure is found on Sulphur island in Thunder Bay and also at Paxton, Alpena county. The Antrim shale, when fresh, contains much organic matter, but when weathered, it is very suitable for use in making Portland cement, common and vitrified brick and tile.

## TRAP ROCK.

Trap rock is quarried on an extensive scale in the vicinity of Marquette and large quantities are taken out in connection with copper mining in Houghton and Keweenaw counties. The trap rock from Marquette is harder, tougher, and much less altered than the amygdaloid trap produced by the copper mines. The inferior wearing qualities of the latter for road making are partly compensated for by most superior cementing power.

Most of the quarry product is crushed for concrete and road making. On account of its hardness, toughness, and high cementing power, it is unexcelled as a road metal. Unfortunately the great distance from thickly settled communities and the high cost of quarrying are serious obstacles in preventing the development of the trap rock industry.



## PRODUCTION AND VALUE OF TRAP ROCK IN MICHIGAN, 1911-1913.

Year.	No. of producers.	Crushed stone.				Riprap. value.	Total value.
		Road making.		Concrete.			
		Quantity.	Value.	Quantity.	Value.		
		Tons.		Tons.			
1911.....	3			45,250	\$38,429		\$51,000
1912.....	5	21,805	\$18,366	11,355	9,340	\$8,500	36,206
1913.....	5	24,920	23,369	c	c	c	92,201
Total...		46,725	\$41,735				\$179,407

(c) Included in total.

## GRINDSTONES AND SCYTHESTONES.

Large quantities of grindstones and scythestones are produced in Huron county by the Wallace Co., at Eagle Mills near Point Aux Barques, and by the Cleveland Stone Co. at Grindstone City. The grindstones vary in size from very small ones up to those seven feet in diameter with a 14 inch face. The broken stone is worked up into scythestones.

The sandstone, a grit stone, occurs in low lying ledges near the shore of Lake Huron. The rock after being stripped of a thin veneer of drift is cut up into square blocks by channelling machines.

As there are but two producers no tables of production and value can be given.

## THE MICHIGAN SLATE INDUSTRY.

BY O. R. HAMILTON.

The slate quarries at Arvon were abandoned 10 years ago and the property, which is in a general state of dilapidation, was recently acquired by the Marshall Butters Lumber Co. operating mills at L'Anse. The earliest work was done by the Huron Bay Slate & Iron Co. organized in 1872. Preparatory work was started in the fall of the same year. A tramway was built to Huron Bay where a dock was later constructed to load the slate from the quarries on section 28, T. 51, N., R. 31 W., directly into lake steamers of 14 foot draught. By 1877 the company had exhausted its resources after making meager shipments. Previous to 1878, 5,100 squares of roofing

slate had been shipped and during the year 1878, 1,535 squares were sent out.

In 1874 the Clinton Slate & Iron Co. began work in a small quarry on section 33, T. 51 N., R. 31 W. The resulting success is best shown by the shipments:

1875.....	405 squares of roofing slate.
1876.....	1,045 squares of roofing slate.
1877.....	1,034 squares of roofing slate.
1878.....	600 squares of roofing slate.
Total.....	3,084 squares of roofing slate.

These companies ended their operations in ruin and their holdings were acquired by the Michigan Slate Co. formed by Jackson and Lansing capitalists in 1881. The officers were James Turner, W. K. Prudden, S. F. Seager and S. L. Smith of Lansing, Mich. With a capital of \$500,000 the new company started extensive improvements, of which we now see the ruins, the dock on Huron Bay with connecting railroad, engine house, saw mill, blacksmith shop, carpenter shop, stable, 14 dwelling houses, a two story hotel which cost \$10,000, all now going to decay except one dwelling occupied by a caretaker.

Following is a table of the production of slate for the state, which means for the quarries at Arvon since slate has been quarried from no other section in Michigan. The production for the United States is given to show relative values of the Michigan slate and that of other regions.

Michigan production of slate from Bulletin 275, U. S. Geological Survey. Shipments for years previous to 1883 not reported:

1883...	5,000 squares of roofing slate valued at	\$18,250	or	\$3.65 per square.
1884...	7,000 squares of roofing slate valued at	35,300	or	5.04 per square.
1885...	10,000 squares of roofing slate valued at	40,000	or	4.00 per square.
1886...	12,000 squares of roofing slate valued at	46,000	or	3.83 per square.
1887...	7,000 squares of roofing slate valued at	25,000	or	3.57 per square.
1888...	7,000 squares of roofing slate valued at	24,000	or	3.43 per square.
Total.	48,000 squares of roofing slate valued at	\$188,550	Av.	\$3.93 per square.

No mention is made of any milled stock being shipped although sample blocks from which slabs three and one-half by five and one-half feet could be machined were sent to Chicago and Detroit for the inspection of billiard table and mantel manufacturers.

During the same period the production for the United States was 3,296,793 squares of roofing slate valued at \$10,764,709 or at an average of \$3.26 per square in addition to which \$18,000 value of milled stock was produced. Since 1888 milled stock has amounted to 15 per cent of the total production of the United States. Prices given above are f. o. b. at the quarries.

The slates suitable for roofing are found on the northwest side of

the Huron Mountain Range in the vicinity of Huron Bay. The thickness of the strata is uncertain, but great, while only locally is the slate of fine texture and sufficiently free from fracture planes to be of commercial value. The roofing slate which was sent out from the quarries at Arvon is of an agreeable black color and of uniform quality. The grain is fine, silky, homogeneous and combines durability with smoothness, bearing favorable comparison with the product from the Eastern quarries.

Cleavage or splitting planes of the slate in the quarries dip very uniformly to the south, but the bedding plane is in broad anticlinal and synclinal waves which trend east and west with a consequent dip to the south or north as the case may be.

In the Huron Bay quarry (located S. W.  $\frac{1}{4}$  of S. E.  $\frac{1}{4}$  of sec. 28, T. 51 N., R. 31 W.) the formation dips 15 degrees to the north while the cleavage dips 30 degrees to the south; in the Clinton quarry, which is close to the section line in the N. W.  $\frac{1}{4}$  of section 33, T. 51 N., R. 31 W., the bedding dips 12 degrees to the south, nearly conforming to the cleavage which dips at a slightly steeper angle of 30 degrees. The strike is N. 85° W.

The process of quarrying was attended with great waste and the management of the early quarrying has been criticised by Dr. Rominger and other writers. However, it is true that the output was comparatively small and in absence of accurate data it is reasonably sure that the work in the quarries was hindered by many natural difficulties. The early companies exhausted their capital and left the property littered up with refuse, which placed an added burden on the later management.

A. P. Swineford, Commissioner of Mineral Statistics, in his report for 1884 says of the slate industry: "The time is near at hand when the slate interest of Baraga county will come to the front and take rank as one of the most important of our Michigan industries. Indeed all that is now needed to make it a permanently profitable industry is the employment of the capital (backed by intelligent management) necessary to its thorough development."

Occurrence of workable slates has been reported in various localities. Among these are, sec. 19, T. 51 N., R. 29 W., and sec. 24, T. 51 N., R. 29 W., in Marquette county; sec. 14, T. 48 N., R. 34 W., sec. 6 and 7 in T. 50 N., R. 32 W., and sec. 16 and 17 in T. 50 N., R. 33 W., all in Baraga county.

Literature on the Slate Industry of Michigan includes, Volume III, 1873-1876, Dr. C. Rominger's report to the Board of Geological Survey, pages 159-166.

Michigan Mineral Statistics, beginning with the year 1878, particularly volumes 1878, 1881, 1882, 1884.

Bulletin 275, United States Geological Survey, by T. Nelson Dale and others. Table of Production of Slate by States.

### SAND AND GRAVEL.

The present era of concrete in the United States dates from about 1895, the production of Portland cement growing from less than 1,000,000 barrels in that year to over 92,000,000 barrels in 1913. Sand and gravel are the chief materials used in concrete aggregates hence the sand and gravel industry has grown in importance hand in hand with that of cement. In 1904 the former industry in Michigan had become of such importance that statistical data were collected by the U. S. Geological Survey. A further impetus has been given to the industry during the past few years through the inauguration of the state wide propaganda for good roads.

Owing to the large number of sand and gravel pits, their short life, the desultory manner in which most of the smaller ones are operated, the difficulty of obtaining a directory of the producers in rural communities and of securing returns, the statistical data have been more or less incomplete and unsatisfactory. Up to 1913, the sand and gravel directory contained only about 125 names and these were chiefly of operators in the vicinity of cities and towns, hence the tabulations represent chiefly the status of the industry as developed in urban communities. In 1912, in co-operation with the State Highway Department, an effort was made to obtain a more complete directory of the producers especially for the rural districts with the net results that the location of about 3,000 sand and gravel deposits and the addresses of nearly 2,000 new producers were secured. A large part of the apparent increase in production in 1913 is due to the much larger number of reports received from the producers.

Michigan has enormous sand and gravel resources. Only a small portion has been developed and this is chiefly in the vicinity of towns and cities, or favorable means of transportation. The most extensive developments have been made in Berrien, Kalamazoo, Calhoun, Kent, Ingham, Oakland, Washtenaw, Macomb, and Huron counties. Extensive dredging operations are carried on in St. Clair river and along the shore of Lake Huron.

## GRAVEL FOR CONCRETE AGGREGATES.

During the past year, numerous tests have been made upon sand and gravel by the Universal Portland Cement Co. of Chicago to determine the fitness of such material for use in concrete work and the results of these tests have been furnished the Geological Survey through the kindness of Mr. C. W. Boynton and Mr. E. F. Smith of the Information Department of the company. Further tests were conducted on the sand and gravel deposits of Ingham county by F. W. Schmidt, a student engineer in the Michigan Agricultural College, who kindly presented the Geological Survey with a copy of his investigations and tests.

The results of the investigations and tests show that, in general, pit run material in Michigan is unfitted for use as a concrete aggregate. The reason for this lies in the facts (1) that the natural material is not properly graded and (2) that various injurious impurities are present in most sand and gravel.

Concrete aggregates are usually classed as fine and coarse, according to the size of the particles. The dividing line generally accepted is one-fourth inch diameter. The air spaces between the particles are termed the voids and are generally referred to as a percentage of the whole. Tests upon nearly 200 different sands show that the percentage of voids ranges from 29 to 44 per cent, the smaller percentages predominating. If the aggregate consists of grains of nearly uniform size, the percentage of voids approaches a maximum and is generally too large for the cement to fill, consequently the concrete made from such material is porous and lacks the necessary cement bond to give it strength. This is especially true in coarse aggregates having but little fine material to fill up the large voids. The failure of much concrete pavement can be traced to poorly graded aggregates, the concrete crumbling and cracking to pieces under ordinary traffic. An ideal mixture should consist of material grading from coarse to fine in such proportions that the percentage of voids would be reduced to a minimum. This insures a more perfect bond between the individual grains with a minimum amount of cement. The finer the aggregate, the greater is the total amount of surface. This surface must be covered by cement, if a perfect bond between the grains is to be secured, therefore fine aggregates require a greater amount of cement than coarse ones, other things being equal. Pit run material generally does not consist of a proper mixture of the finer and coarser aggregates, hence it should be screened and then mixed in the proper proportions. Experience and tests have demonstrated that

the mixture should consist of about half as much fine as coarse aggregate. In pit run gravel, generally the fine material makes up half or more than half of the total bulk. Tests show that, in general, with a given proportion of cement, concrete made from screened and properly graded gravel develops greater strength than that made from unscreened and poorly graded gravel.

Nearly all sand and gravel contains impurities in the form of clay, silt, oxides or organic matter. The effect of clay or silt on concrete has been investigated by many students of concrete aggregates and widely different conclusions have been drawn. It appears, however, that clay, when present even in small amounts as a coating on the particles of sand, is undoubtedly injurious, because it prevents the adhesion of the cement to the sand particles. When it exists as separate particles scattered throughout the mass of aggregate, it appears to be harmless, and, in case of poorly graded aggregates, it may be of value in filling up the voids. Clay, when present in amounts more than four or five per cent, may dilute the cement to such an extent that the cement bond is soft and friable.

Organic matter is unquestionably injurious and generally exists in the form of roots and as a dust coating on the particles. This organic dust gives a "dead" appearance to sand when dry and its physical effect is similar to that of clay, but, in addition, it appears to have a deleterious chemical effect on the aggregate. The organic matter and clay, when present in considerable amounts, may cause the concrete to harden so slowly that constructive operations are interfered with. In many cases such concrete never develops any great strength and the use of material with much organic matter or clay should be prohibited.

Clay, silt and organic matter may be almost completely removed by washing and the tests show that in general the strength of the concrete is greater with washed than with unwashed material, provided properly graded material is used.

## MINERAL RESOURCES OF MICHIGAN.

## PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1904-1913.

Year.	Glass sand.		Molding sand.		Building sand.		Fire sand.		Engine sand.	
	Quan- tity.	Value.	Quan- tity.	Value.	Quan- tity.	Value.	Quan- tity.	Value.	Quan- tity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.	
1904			167,147	\$76,299	69,656	\$30,898				
1905			19,382	13,247	263,315	148,065	5,000	\$2,500		
1906	600	\$3,000	61,387	26,108	403,199	127,937			4,000	\$400
1907	4,300	8,600	54,172	24,190	451,646	157,150	6,000	3,000	1,534	153
1908	17,000	34,000	4,584	2,892	474,238	228,395			1,991	319
1909	65,000	79,000	53,226	20,756	1,090,419	327,247	4,000	2,000	12,415	1,493
1910	16,212	25,675	93,812	24,004	1,151,588	334,336	5,000	3,000	22,270	2,172
1911	a	a	68,878	17,901	833,729	247,997	a	a	25,392	4,447
1912	a	a	152,433	40,145	902,556	294,115			18,575	4,774
1913	a	a	50,763	17,493	1,326,016	415,737	4,542	4,524	4,447	647
Totals			725,784	263,035	6,966,362	2,311,877			90,624	14,405

## PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1904-1913.

Year.	Furnace sand.		Paving sand.		Other sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.	
1904						
1905					50,187	\$14,476
1906	5,000	\$2,500			51,005	12,140
1907	3,858	3,133			173,724	12,187
1908	3,329	3,828			29,187	6,850
1909	3,183	3,660			295,612	50,953
1910	3,185	4,924			372,880	57,385
1911	a	a	152,144	\$29,650	114,801	52,005
1912			68,453	16,898	130,624	54,746
1913	b	b	533,261	108,328	113,318	20,342
Totals			753,858	154,876	1,331,338	281,084

Year.	Gravel.		Total.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.	
1904			236,803	\$107,197
1905	76,625	\$32,321	414,509	210,609
1906	72,598	25,614	597,789	197,699
1907	329,407	81,182	1,024,641	289,595
1908	312,262	94,081	842,591	370,365
1909	695,902	200,523	2,219,757	685,632
1910	1,197,791	364,841	2,862,738	816,337
1911	935,072	203,218	2,185,165	565,969
1912	1,409,180	407,925	2,681,821	818,603
1913	3,928,874	915,205	6,422,818	1,528,892
Total	8,957,711	\$2,324,910	19,488,632	\$5,590,898

a Included under other sand.

b Included under fire sand.

## SALT.

The production and value of salt in Michigan for 1913 were greater than for any previous year. The total amount of brine and rock salt was 11,528,800 barrels valued at \$3,293,032. This was an increase in quantity of 582,061 barrels and, in value, of \$318,603. The average price per barrel was \$0.285, the highest since 1901, excepting in 1904 when the average price was \$0.309 per barrel. Since 1905, the average price per barrel has gradually risen from \$0.196 to the present figure.

Thirty years ago most of the salt was produced in Saginaw Valley, chiefly along Saginaw river from Saginaw to Bay City. The industry was carried on in connection with the lumber industry, utilizing the waste steam and fuel of the saw mills to evaporate the brines, which were obtained from the Marshall sandstones at depths varying from about 600 feet at Saginaw to nearly 1,000 feet at Bay City. With the decline of lumbering in the Saginaw Valley, the salt industry along Saginaw river has become relatively unimportant, only about 3% of the total output of the state coming from this region in 1913.

The chief salt producing districts are at Ludington and Manistee and along Detroit and St. Clair rivers, where artificial brines are utilized in the manufacture of salt. Rock salt is also mined at Oakwood, a small suburb of Detroit. Over 96% of the total production of the state comes from these two districts. The most remarkable growth of the salt industry has occurred in Wayne county. Salt was first produced in this county in 1895, the total output being 13,077 barrels. In 1906 the production exceeded 1,000,000 barrels and in 1913 the total output was approximately 6,385,000 barrels. Most of this production is in the form of brine, which is used in the manufacture of soda ash, bleach, caustic, etc. The Solvay Process Co. of Delray, the Michigan Alkali Co. at Ford City and Wyandotte, and the Pennsylvania Salt Co. at Wyandotte use great quantities of brine in the manufacture of such products.

St. Clair county produces only about 15.5% of the quantity but nearly 39% of the value of the salt output of the state. The explanation of this lies in the fact that much of the salt produced in this county is of the finer grades, over 45% being table and dairy salt.

Bromine and calcium chloride are made at Mt. Pleasant, Midland and Saginaw.

The rock salt beds are encountered at about 1,900 feet below the surface at Manistee and 2,300 feet at Ludington. The total observed thickness of the salt beds in the Ludington-Manistee district is from



20 to 44 feet. In the Detroit-St. Clair rivers district, the first salt is struck at depths varying from 730 feet at Wyandotte to 1,500 and 1,600 feet, respectively, at Port Huron and St. Clair. The average aggregate thickness of the various beds appears to be about 400 feet along Detroit river, but at Royal Oak, Oakland county, salt beds aggregating 609 feet were penetrated without reaching the bottom of the Salina or rock salt bearing formation.

Drill holes at Alpena, Grand Lake, and Onaway in Alpena and Presque Isle counties show that the salt beds have a great development in the northeastern part of the Southern Peninsula. The salt beds penetrated at Grand Lake aggregate over 300 feet and at Onaway over 800 feet in thickness. The Ludington-Manistee, the Detroit-St. Clair rivers, and the Alpena-Presque Isle county rock salt districts are probably but parts of one and the same great rock salt area.

## NONMETALLIC MINERALS.

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PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES,  
1860-1913.

Year.	U. S. production. Quantity. bbls.	Michigan production.		Per cent of total. Michigan.	Rank of state quantity.	Value. Michigan.	Price. Michigan.
		State Salt Inspectors.* Quantity. bbls.	U. S. G. S. Quantity. bbls.				
1860.		4,000					
1861.		125,000					
1862.		243,000					
1863.		466,000					
1864.		529,073					
1865.		477,200					
1866.		407,997				\$734,395	\$1.80
1867.		474,721				840,255	1.77
1868.		555,690				1,028,027	1.85
1869.		561,288				786,835	1.58
1870.		621,352				820,185	1.32
1871.		728,175				1,063,135	1.46
1872.		724,481				1,057,742	1.46
1873.		821,346				1,127,984	1.37
1874.		1,026,970				1,220,094	1.19
1875.		1,081,856				1,190,042	1.10
1876.		1,482,729				1,556,865	1.05
1877.		1,660,997				1,411,847	0.85
1878.		1,855,884				1,577,501	0.85
1879.		2,058,040				2,099,200	1.02
1880.	5,961,060	2,676,588	2,485,177	41.69	1	2,271,931	0.75
1881.	6,200,000	2,750,299		44.35	1	2,418,171	0.85
1882.	6,412,373	3,037,317	3,037,317	47.36	1	2,126,122	0.70
1883.	6,192,231	2,894,672	2,894,672	46.74	1	2,344,684	0.81
1884.	6,514,937	3,161,806	3,161,806	48.53	1	2,392,648	0.757
1885.	7,038,653	3,297,403	3,297,403	46.84	1	2,967,663	0.900
1886.	7,707,081	3,667,257	3,667,257	47.58	1	2,426,989	0.661
1887.	8,003,962	3,944,309	3,944,309	49.17	1	2,291,842	0.581
1888.	8,055,881	3,866,228	3,866,228	47.99	1	2,261,743	0.585
1889.	8,005,565	3,846,979	3,856,929	48.17	1	2,088,909	0.541
1890.	8,776,991	3,838,637	3,838,632	43.72	1	2,302,579	0.600
1891.	9,987,945	3,927,671	3,966,748	39.52	1	2,037,289	0.513
1892.	11,698,890	3,812,504	3,829,478	32.81	1	2,046,963	0.523
1893.	11,897,208	3,514,485	3,057,898	25.70	2	888,837	0.287
1894.	12,968,417	3,138,941	3,341,425	26.53	2	1,243,619	0.375
1895.	13,669,649	3,529,362	3,343,395	24.46	2	1,048,251	0.315
1896.	13,850,726	3,336,242	3,164,238	22.89	2	718,408	0.229
1897.	15,973,202	3,622,764	3,993,225	24.99	2	1,243,619	0.313
1898.	17,612,634	4,171,916	5,263,564	29.88	2	1,628,081	0.311
1899.	19,708,614	4,732,669	7,117,382	36.14	2	2,205,924	0.309
1900.	20,869,342	4,788,085	7,210,621	34.55	2	2,033,731	0.282
1901.	20,566,661	5,580,101	7,729,641	37.58	1	2,437,677	0.328
1902.	23,849,231	4,994,245	8,131,781	34.10	2	1,535,823	0.188
1903.	18,968,089	4,387,982	4,297,542	22.65	2	1,119,984	0.260
1904.	22,030,002	5,390,812	5,425,904	24.62	2	1,579,206	0.309
1905.	25,966,122	5,671,253	9,492,173	35.24	1	1,851,332	0.196
1906.	28,172,380	5,644,559	9,936,802	36.31	1	2,018,760	0.203
1907.	29,704,128	6,298,463	10,786,630	35.39	1	2,231,129	0.208
1908.	28,822,062	6,247,073	10,194,279	35.34	1	2,458,303	0.241
1909.	30,107,646	6,055,661	9,966,744	33.10	1	2,732,556	0.274
1910.	30,305,656	5,597,276	9,452,022	31.18	2	2,231,262	0.236
1911.	31,183,968		10,320,074	33.10	2	2,633,155	0.255
1912.	33,324,808		10,946,739	32.84	1	2,974,429	0.277
1913.	34,393,227†		11,528,800	33.52	1	3,293,032	0.285
Tot'ls			197,546,836			\$86,598,758	

\*Office of State Salt Inspector abolished in 1911.

†Includes production of Porto Rico.

## MINERAL RESOURCES OF MICHIGAN.

## PRODUCTION AND VALUE OF SALT IN MICHIGAN BY GRADES, 1906-1913.

Year.	Table and dairy.		Common fine.		Common coarse.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906....	509,905	\$362,368	2,927,478	\$757,470	2,021,287	\$618,727
1907....	657,509	392,641	3,601,270	914,154	1,743,840	471,378
1908....	584,452	620,647	3,454,062	968,617	2,020,956	610,286
1909....	585,370	732,907	3,530,303	1,125,095	2,103,719	647,878
1910....	798,434	565,653	2,216,181	734,828	1,992,465	596,301
1911....	817,486	742,702	2,362,075	698,203	2,070,745	745,720
1912....	905,593	920,782	2,225,337	645,692	2,086,492	835,673
1913....	1,028,000	1,037,402	2,704,936	852,135	2,259,164	896,521

Year.	Packers.		Other, rock, etc.		Brine and other.*	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906....	91,098	\$33,733	.....	.....	4,387,043	\$246,462
1907....	119,459	48,455	.....	.....	4,664,552	235,729
1908....	134,726	53,669	.....	.....	3,991,083	205,084
1909....	93,357	3,983	.....	.....	3,648,395	185,051
1910....	92,426	43,942	.....	.....	4,104,934	211,317
1911....	105,401	45,421	576,595	\$181,865	4,387,772	219,244
1912....	223,866	84,638	763,908	250,680	4,737,038	236,852
1913....	50,557	25,371	727,364	244,172	4,756,779	237,431

Total.					Total.	
					Quantity.	Value.
					Barrels.	
1906.....					9,936,802	\$2,018,760
1907.....					10,786,630	2,062,357
1908.....					10,194,270	2,458,303
1909.....					9,966,744	2,732,556
1910.....					9,452,022	2,231,263
1911.....					10,320,074	2,633,155
1912.....					10,946,739	2,974,429
1913.....					11,528,800	3,293,032

\*Brine only after 1910.

## PRODUCTION AND VALUE OF SALT IN MICHIGAN BY COUNTIES IN 1913.

County.	Table and dairy.		Common fine.		Common coarse.		Packers.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Bay.....	b	b	98,168	\$205,435	39,970	\$148,271		
Isabella.....								
Mason.....								
Midland.....								
Manistee.....			161,169	317,082	98,295	297,462	a	a
Saginaw.....			13,367	49,991	37,275	104,851		
St. Clair.....	114,515	\$874,072	60,641	173,422	78,684	216,211	a	a
Wayne.....	22,221	86,356	45,346	106,205	67,059	129,726		
State total tns.	143,920	\$1,037,402	378,691	\$852,135	316,283	\$896,521	7,078	\$25,371
total bls.	1,028,000		2,704,936		2,259,164		50,557	

County.	Other grades.		Rock salt.		Brine.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Bay.....					a	a	151,047	\$432,316
Isabella.....								
Mason.....								
Midland.....								
Manistee.....	a	a					265,594	631,686
Saginaw.....	a	a					50,688	155,004
St. Clair.....	a	a					252,748	1,276,268
Wayne.....			b	b	a	a	893,955	797,758
State total tns.	102,111	\$244,172			665,949	\$237,431	1,614,032	\$3,293,032
total bls.	727,364				4,756,779		11,528,800	

(a) Included in total.

(b) Included under Other Grades.

## CEMENT.

The present era of cement concrete construction dates from about 1895, when less than 1,000,000 barrels of Portland cement were produced in the United States. From this date, until checked by the general depression in 1907, there was a phenomenal growth in the cement industry, nearly 48,000,000 barrels being produced in that year. This remarkable growth was resumed in 1908 and has continued to the present when the total production for the United States in 1913 was over 92,000,000 barrels.

The "boom" years of the cement industry in Michigan were between 1899 and 1901, the production growing from less than 350,000 barrels in 1899 to more than 1,000,000 in the latter year. By 1907 the production had increased to nearly 3,750,000 barrels, but the financial depression in 1907 caused a large decrease in 1907-08. Al-

though low prices prevailed from 1907 up to the latter part of 1912, the growth continued until the total production in 1913 reached nearly 4,100,000 barrels, the largest in the history of the industry in Michigan. From 1907 to 1912 the average price of cement in Michigan was 85 cents or below per barrel with the exception of 1911 when the price was a little over 89 cents. During the latter part of 1912, the price of cement materially increased and this increase prevailed throughout the season of 1913, the average price being \$1.036 per barrel. During the period of low prices little or no profit was made by any of the companies and some experienced severe losses and went out of business, the number of plants decreasing from fifteen to eleven.

On account of freight rates and competition from extra-state cement, Michigan cement is largely confined to local markets. With the larger number of plants of prior years, the capacity for production was much greater than local consumption. Most of the plants were thus forced to be idle part of the time or to run at less than normal capacity. The decrease in the number of cement plants and the increased use of cement enable the remaining plants to work at or near their maximum capacity with consequent reduction in the average cost per barrel. The larger consumption and the higher prices of cement make the outlook for the cement industry in Michigan much brighter than since 1907.

A comparison of the following tables show that for 1913 Michigan produced 4,186,236 barrels of cement, or nearly 692,000 barrels more than in 1912, but the shipments in 1913 exceed those of 1912 by only about 430,000 barrels. This was due in part to the fact, that, in 1912, there was a decrease in production on account of the large stocks held over from 1911 and that the high prices during the latter part of 1912 resulted in heavy sales and a consequent reduction of the stocks. Also, upon the advent of higher prices most of the plants made preparation for a large production in 1913, some plants being closed down in the fall of 1912 for a thorough overhauling and refitting. While the increase in sales was only 430,000 barrels, the increase in value was nearly \$1,084,000, a reflection of the higher average price of cement.

PRODUCTION, VALUE, ETC., OF PORTLAND CEMENT IN MICHIGAN AND UNITED STATES, 1896-1913.

Year.	No. of plants in operation.	Michigan Rank.	No. of kilns, Rotary.	Daily capacity.	Michigan Cement made. Bbls.	U. S. Cement made. Bbls.	Michigan Per cent made.	Change Per cent in production.	Michigan Cement shipped. Bbls.	Michigan Cement shipped. Value.	U. S. Cement shipped. Value.	Michigan Per cent of value.	Michigan Stock on hand Dec. 31. Bbls.	Michigan average price per barrel.	U. S. average price per barrel.
1896	1	1	4,000	.....	1,543,023	1,543,023	0.25	.....	.....	\$7,000	2,424,011	0.29	.....	\$1.75	\$1.57
1897	2	1	15,000	.....	2,677,775	2,677,775	0.56	275.0	.....	26,250	4,315,891	0.60	.....	1.75	1.61
1898	2	1	77,000	.....	3,692,284	3,692,284	2.11	413.3	.....	134,750	5,970,773	2.3	.....	1.747	1.63
1899	4	2	343,566	.....	5,652,266	5,652,266	6.1	346.2	.....	513,849	8,074,871	6.36	.....	1.432	1.43
1900	6	2	664,750	.....	8,482,020	8,482,020	7.8	93.4	.....	830,990	9,280,525	8.9	.....	1.25	1.09
1901	10	3	1,025,718	.....	12,711,225	12,711,225	8.0	54.1	.....	1,128,290	12,532,369	9.0	.....	1.10	0.99
1902	10	3	1,577,006	.....	17,230,644	17,230,644	9.1	53.7	.....	2,134,396	20,864,078	10.2	.....	1.353	1.21
1903	13	3	1,955,183	.....	22,342,973	22,342,973	8.7	23.9	.....	2,674,780	27,713,319	9.7	.....	1.367	1.24
1904	16	4	2,247,160	.....	26,505,881	26,505,881	8.5	14.9	.....	3,365,656	33,355,119	10.1	.....	1.052	0.88
1905	16	5	2,773,283	.....	35,246,812	35,246,812	7.9	23.4	.....	2,921,507	33,245,867	8.7	.....	1.053	0.94
1906	14	4	3,747,525	.....	46,463,424	46,463,424	8.06	35.5	.....	4,814,965	52,466,186	9.2	.....	1.284	1.13
1907	14	4	3,572,668	.....	48,785,390	48,785,390	7.3	4.6	.....	4,384,731	53,992,551	8.1	.....	1.237	1.11
1908	15	7	2,892,576	.....	51,072,812	51,072,812	5.6	19.0	.....	2,556,215	43,547,879	5.8	.....	0.883	0.85
1909	12	7	3,212,751	.....	64,991,431	64,991,431	4.9	11.6	.....	2,619,259	52,858,354	4.9	.....	0.815	0.813
1910	12	8	3,687,719	.....	76,549,951	76,549,951	4.8	11.7	.....	3,378,940	68,205,800	4.9	.....	0.816	0.891
1911	11	8	3,686,716	22,400	78,528,637	78,528,637	4.89	0.03	.....	3,024,676	66,248,817	4.56	506,758	0.820	0.843
1912	11	8	3,494,621	19,450	82,438,096	82,438,096	4.23	5.21	3,651,064	3,145,001	69,109,800	4.55	370,956	0.861	0.813
1913	11	8	4,186,236	19,900	92,097,131	92,097,131	4.21	+19.79	4,081,281	4,228,879	88,689,377	4.77	473,563	1.036	1.005

NONMETALLIC MINERALS.

## GYPSUM.

The annual production of gypsum in Michigan from 1868 to 1890 inclusive never reached 75,000 tons. During the next three years, there was a large increase, a total of nearly 140,000 tons being mined in 1892. The financial depression in the United States in 1892-3 caused a large decrease and only about 66,500 tons were mined in 1895. By 1899 the gypsum industry had recovered from the effects of the depression and nearly 145,000 tons were produced. Since the invention of gypsum wall plasters and other gypsum products, the industry has made a rapid growth and nearly 424,000 tons were mined in 1913.

From 1868 to 1887, more than half of the gypsum produced was ground and sold as land plaster. Since 1887, the grinding of land plaster has become of less and less importance, only 9,600 tons being ground in 1913. More than 85% of the gypsum mined in 1913 was calcined and sold as plaster of Paris, stucco, or used in the manufacture of wall plaster, plaster board, fire proofing, various cements, and calcimines. The mining or quarrying of gypsum has become relatively unimportant in comparison with the business of manufacturing gypsum products.

In 1913, seven mines and quarries and eight mills were operated. Six mines or quarries and seven mills are located near Grand Rapids and Grandville, Kent county. One quarry and mill is located at Alabaster in southeastern Iosco county.

Three gypsum beds are worked in Kent county. The two upper beds respectively 6 and 12 feet in thickness, are near the surface. The first is quarried and the second is both quarried and mined. The third bed about 60 feet below the second is 22 feet thick and is divided near the center by a shale parting a foot or less in thickness. At Alabaster, the gypsum bed is from 18 to 23 feet thick and is quarried on a very extensive scale. In Arenac county, another gypsum bed 50 to 100 feet above the Alabaster bed has been located near Turner and Twining and the deserted village of Harmon City on Lake Huron. This, bed, called the Turner, appears to be from 6 to 22 feet in thickness.

According to the records of test holes drilled north of Alabaster, there are a number of gypsum beds from 5 to 25 feet in thickness below the Alabaster bed. Coal drillers have reported the discovery of thick beds of pure gypsum in several places in the Coal Measures of Saginaw valley. While drilling test wells for the city of Ionia, E. E. Strobe and A. G. Lang of Mason reported the discovery of a bed of pure gypsum from 4 to 30 feet in thickness. The gypsum was struck above the depth of 105 feet which would indicate that the

bed is in the Coal Measures. Further investigation must be made before a definite assertion is warranted. The sample of gypsum submitted to the Geological Survey by Mr. Strobe was of the selenite variety,

## PRODUCTION OF GYPSUM IN MICHIGAN, 1868-1913.

Year.	Ground into land plaster. Tons.	Gypsum calcined into plaster. Tons.	Sold crude. Tons.	Total production. Tons.	Total value.
Before 1868.....	132,043	14,285		146,328	\$671,022
1868.....	28,837	6,244		35,081	165,298
1869.....	29,996	7,355		37,351	178,824
1870.....	31,437	8,246		39,683	191,718
1871.....	41,126	8,694		49,820	234,054
1872.....	43,536	10,673		54,209	259,524
1873.....	44,972	14,724		59,696	297,678
1874.....	39,126	14,723		53,849	274,284
1875.....	27,019	10,914		37,933	195,386
1876.....	39,131	11,498		50,629	248,504
1877.....	40,000	9,819		49,819	238,550
1878.....	40,000	8,634		48,634	229,070
1879.....	43,658	9,070		52,728	247,192
1880.....	49,570	18,929		68,499	349,710
1881.....	33,178	20,145		53,323	293,872
1882.....	37,821	24,136		61,957	344,374
1883.....	40,082	28,410		68,492	377,567
1884.....	27,888	27,959		55,847	335,382
1885.....	28,184	25,281		53,465	286,802
1886.....	29,373	27,370		56,748	308,094
1887.....	28,794	30,376		59,170	329,392
1888.....	22,177	35,125		57,302	347,531
1889.....	19,823	36,800		56,623	353,869
1890.....	12,714	47,163	15,000	74,877	192,099
1891.....	15,100	53,600	11,000	97,700	223,725
1892.....	14,458	77,599	47,500	139,557	306,527
1893.....	16,263	77,327	31,000	124,590	303,921
1894.....	11,982	47,976	20,000	79,958	189,620
1895.....	9,003	51,028	6,458	66,519	174,007
1896.....	6,582	60,352	700	67,634	146,424
1897.....	7,193	71,680	16,001	94,874	193,576
1898.....	13,345	77,852	1,984	93,181	204,310
1899.....	17,196	88,315	39,266	144,776	283,537
1900.....	10,354	86,972	33,328	129,654	285,119
1901.....	9,808	129,256	46,086	185,150	267,243
1902.....	13,022	158,320	68,885	240,227	459,621
1903.....	18,409	198,119	52,565	269,093	700,912
1904.....	18,294	185,422	34,669	238,385	541,197
1905.....	20,285	203,313	24,284	247,882	634,434
1906.....	30,220	208,715	27,517	341,716	753,878
1907.....	15,500	197,666	36,543	317,261	681,351
1908.....	11,414	192,403	40,324	327,810	491,928
1909.....	11,890	344,171	45,781	394,907	1,213,847
1910.....	7,097	240,905	64,566	357,174	667,199
1911.....	15,548	206,299	79,050	347,296	523,926
1912.....	10,163	243,656	63,819	384,297	621,547
1913.....	9,604	278,368	60,706	423,896	721,325
Totals.....	1,223,155	3,935,987	867,062	6,501,570	17,538,470



## PRODUCTION OF GYPSUM IN MICHIGAN 1911-1913.

Year.	Gypsum sold crude.									
	Crude gypsum mined.		To Portland Cement Mills.		As land plaster.		For other purposes.		Total sold crude.	
	Quantity.		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.	
1911.....	347,296		63,489	\$89,497	15,548	\$15,706	13	\$52	79,050	\$85,255
1912.....	384,297		53,711 <sup>a</sup>	52,420	10,103	9,375	5	50	63,819	61,845
1913.....	423,896				9,604	10,222	10,320	9,011	60,706	55,969
Gypsum sold calcined.										
Year.	As mixed with wall plaster.		As plaster of Paris, etc.		As stucco.		As dental plaster.		To plate glass works.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.	
1911.....	146,920	\$381,362	47,969	\$88,168			20	\$110	11,370	\$19,031
1912.....	146,099	368,676	937	3,229	82,010	\$168,734	3	12	6,214 <sup>a</sup>	8,078 <sup>a</sup>
1913.....	166,711	437,720			95,402	202,675				

(a) Included in total.

NONMETALLIC MINERALS.

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PRODUCTION OF GYPSUM IN MICHIGAN, 1911-1913.—*Concluded.*

Year.	Gypsum sold calcined.				Total value.	Kettles in mill.		Daily capacity of mill.	Shifts run by mills during year.		No. mines and quarries.	No. mills.	
	For other purposes.		Total sold calcined.			No.	Size.		24 hrs.	Total No.			Hrs. in shift.
	Quantity.	Value.	Quantity.	Value.									
	Tons.		Tons.					Tons.					
1911.....	8,393	\$10,973	206,299	\$488,671	\$573,926	29	8 x 10	2,200 +			8	8	
1912.....	9,897	15,850	243,656	559,702	621,547	28	8 x 10	2,140	1,850	11	6	8	
1913.....			278,368	665,356	721,325	28	8 x 10	1,785	1,368	11	7	8	

## CLAY.

The clays of Michigan belong in general to three classes, viz. (1) boulder clays or till, (2) lake clays, and (3) river silts. No deposits of kaolin or china clay are known to exist in Michigan and the chances for the occurrence of kaolin appear to be small. The clays are generally highly calcareous except at the surface where the lime has been more or less leached out to the depth of a few feet.

The boulder clays contain stone and pebbles and, locally, lime concretions which necessitate screening. Screening and washing have been practiced in some instances to remove this coarser material, but the extra expense of washing is generally prohibitive, except in cases where the clay possesses exceptional burning qualities. On account of the high content of lime most of the clays burn white.

The glacial lake clays, though generally high in lime, are freer from pebbles and coarse sand. There are inexhaustible supplies of lake clays along the eastern portion of southern Michigan from Arenac county to the Ohio boundary and these have been developed on a large scale in the vicinity of Detroit. The river silts occur in small deposits more or less variable in character and their generally low lying position makes them difficult to work.

In summary, it may be stated that Michigan possesses unlimited clay resources but they are largely of low grade, being chiefly adapted for making common brick and tile. In Ontonagon and Chippewa counties there are large areas of lake clays and some of those in Ontonagon county are of the slip variety, suitable for glazing pottery. A deposit of slip clay is reported near Harrietta, Wexford county. Further exploration will probably reveal the presence of other deposits of high grade clays. Nearly all of the clay mined and sold as clay in Michigan is of the slip variety, and most of it is obtained from Ontonagon county. A very small amount of the total production is sold for medicinal purposes. The sale of brick clay is incidental to the business of brick making and generally amounts to only a few tons each year.

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## PRODUCTION OF CLAY IN MICHIGAN, 1910-1913.

Year.	Slip clay.		Brick clay.		Miscellaneous clay.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.	
1910...	1,363	\$3,889	60	\$105	1	\$400	1,424	\$4,394
1911...	1,744	5,090	18	32	2	150	1,764	5,272
1912...	2,034	6,184	.....	.....	9	9	2,043	6,173
1913...	1,710	6,504	.....	.....	.....	.....	1,710	6,504
Total..	6,851	21,647	.....	.....	.....	.....	6,941	22,343

## POTTERY.

The value of pottery in 1913 exceeds that of any previous year. There was a marked decrease in the value of red earthenware, produced, but this decrease was more than made up by the increase in the value of porcelain and electrical supplies, art tile and miscellaneous pottery products. But five firms were in operation and one, the Markham Pottery Co. of Ann Arbor, discontinued business in Michigan and removed to California.

Much of the clay used in Michigan in the manufacture of pottery products is imported from other states, few of the local clays being suitable for making the higher grades of pottery.

VALUE OF THE PRODUCTION OF POTTERY IN MICHIGAN, 1899-1913.

Year.	Rank of state.	Firms.	Red earthen-ware value.	Porcelain electrical supplies value.	C. C. ware value.	Miscellaneous value.	Total value.	Per cent of total product in U. S.
1899.....	18	4	\$29,641	.....	\$100	.....	\$29,741	.17
1900.....	17	4	34,217	.....	.....	.....	34,317	.17
1901.....	16	5	42,465	.....	.....	.....	42,565	.20
1902.....	14	4	44,098	.....	.....	.....	44,198	.41
1903.....	16	4	42,007	.....	.....	.....	42,107	.19
1904.....	.....	.....	40,621	.....	.....	.....	40,721	.....
1905.....	.....	5	a	.....	a	.....	.....	.....
1906.....	17	6	43,510	.....	.....	.....	43,610	.16
1907.....	16	6	54,474	.....	.....	.....	54,574	.16
1908.....	16	6	54,659	.....	.....	.....	54,759	.20
1909.....	13	5	60,939	.....	.....	.....	61,039	.25
1910.....	13	6	90,450	a	.....	.....	90,550	.31
1911.....	13	6	80,580	a	a	.....	80,680	.33
1912.....	10	6	99,555	a	.....	.....	99,655	.53
1913.....	10	5	65,000	a	.....	a	65,100	.59
Totals.....	.....	.....	.....	.....	.....	.....	\$1,260,354	.....

(a) Included in the total.

## BRICK AND TILE PRODUCTS.

The quantity and value of brick and tile produced in Michigan in 1913 were greater than in any previous year, the total number of brick of all kinds being 282,664,000, valued at \$1,758,569. The average price per thousand for all grades except vitrified was slightly greater than in 1912. The noteworthy differences in the production in 1913 from that of 1912 are the great decrease in the amount of front brick and the relatively large increase in the production of vitrified brick. The value of tile and other clay products exclusive of brick was \$692,673 in 1913 as compared with \$623,644 in 1912.

The greater portion of the brick and tile produced in Michigan is of the common variety, most of the clays of Michigan being unsuitable for making higher grade products. (See Clay.) Nearly four-fifths of the total production of common brick is made in the vicinity of Detroit. Shale or "fire clay" is used in the manufacture of vitrified brick, tile, stove lining and fire-proofing at Grand Ledge, Jackson, Corunna, Bay City, and Saginaw.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1913.

Year.	Common brick.		Average price per M.	Front brick.		Average price per M.	Vitrified brick.		Average price per M.	Fire brick.		Average price per M.
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.		Quantity.	Value.	
1899.....	200,144,000	\$933,176	\$4.66	4,200,000	\$58,920	\$13.73	a	a	\$12.42	.....	.....	.....
1900.....	180,862,000	863,250	4.77	8,421,000	48,411	5.73	a	a	12.30	.....	.....	.....
1901.....	215,836,000	1,095,254	5.07	6,476,000	68,731	10.61	a	a	12.20	.....	.....	.....
1902.....	237,254,000	1,331,753	5.61	5,654,000	42,763	7.53	a	a	12.20	.....	.....	.....
1903.....	215,791,000	1,231,572	5.80	2,255,000	17,062	7.54	a	a	12.20	.....	.....	.....
1904.....	205,196,000	1,116,714	5.44	2,080,000	17,500	8.04	a	a	12.20	.....	.....	.....
1905.....	211,558,000	1,152,505	5.45	1,693,000	5,905	8.65	a	a	12.20	.....	.....	.....
1906.....	206,583,000	1,178,202	5.70	1,474,000	14,182	9.61	6,112,000	\$81,708	13.37	.....	.....	\$13.00
1907.....	200,817,000	1,181,015	5.88	3,956,000	32,116	8.12	6,229,000	81,814	13.13	.....	.....	19.37
1908.....	181,049,000	1,094,525	5.49	1,896,000	19,490	10.25	7,131,000	94,601	13.08	.....	.....	10.05
1909.....	219,820,000	1,250,787	5.69	2,379,000	18,652	7.84	6,165,000	76,630	12.43	.....	.....	12.00
1910.....	232,551,000	1,363,316	5.86	2,209,000	27,533	12.46	10,473,000	129,283	12.34	.....	.....	.....
1911.....	252,465,000	1,301,998	5.16	2,498,000	31,572	12.46	10,080,000	116,446	12.82	.....	.....	.....
1912.....	271,189,000	1,592,283	5.87	3,934,000	41,476	10.54	5,987,000	78,336	13.00	.....	.....	18.08
1913.....	273,571,000	1,626,287	5.94	5,505,000	5,941	11.76	6,890,000	92,000	13.94	a	a	17.78
							8,571,000	126,062	14.71	a	a	17.41
Totals.....	3,304,716,000	\$18,232,636	.....	50,720,000	\$437,599	.....	66,738,000	\$876,878	.....	.....	.....	.....

(a) Concealed, less than three producers.

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ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1913.—Concluded.

Year.	Stove linings.	Drain tile.	Sewer pipe.	Fire-proofing.	Tile (not drain.)		Miscellaneous.		Hollow building tile or blocks.	Per cent of total product in U. S.	Rank of state.	No. of firms operating.	Total value.
	Value.	Value.	Value.	Value.	Value.	Value.	Value.	Value.					
1899.....	.....	\$140,171	\$50,300	\$5,900	.....	.....	\$22,709	.....	.....	1.68	13	196	\$1,254,256
1900.....	.....	114,747	57,916	2,350	.....	.....	406	.....	.....	1.50	17	189	1,147,378
1901.....	.....	98,972	a	1,880	.....	.....	637	.....	.....	1.71	14	180	1,497,169
1902.....	.....	96,645	a	3,290	.....	.....	.....	.....	.....	1.69	13	182	1,660,942
1903.....	.....	129,028	a	.....	.....	.....	.....	.....	.....	1.58	14	178	1,662,414
1904.....	.....	208,088	a	.....	.....	.....	.....	.....	\$19,138	1.58	14	168	1,670,892
1905.....	.....	205,445	a	a	.....	.....	.....	.....	8,080	1.41	16	154	1,719,746
1906.....	.....	314,098	a	.....	.....	.....	.....	.....	3,585	1.38	16	142	1,793,387
1907.....	.....	289,868	a	.....	.....	.....	.....	.....	4,290	1.39	17	136	1,786,190
1908.....	.....	327,630	a	4,100	.....	.....	1,500	.....	6,386	1.54	16	132	1,666,381
1909.....	.....	364,006	a	a	.....	.....	40,100	.....	.....	1.44	16	122	1,947,059
1910.....	.....	348,205	a	.....	.....	.....	66,128	.....	.....	1.53	15	118	2,083,525
1911.....	.....	313,072	a	.....	a	.....	a	.....	a	1.53	15	.....	1,953,442
1912.....	\$3,971	387,945	a	1,461	a	.....	228,530	.....	a	1.73	13	.....	2,350,806
1913.....	a	415,543	a	a	a	.....	235,459	.....	a	1.73	13	.....	2,350,806
1913.....	.....	.....	.....	.....	.....	.....	350,000	.....	.....	.....	.....	.....	2,451,242
Totals.....	.....	\$3,753,463	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	\$26,644,609

a Concealed under miscellaneous; less than three producers.



## SAND LIME BRICK.

The production of sand lime brick in Michigan has grown from 9,886,000 in 1904 to 49,373,000 in 1913, valued at \$321,245. In both production and value, the amount is more than twice that of any other state. The increase in production has been made not through an increase in the number of plants but by a larger output from each. There were the same number of plants in 1913 as in 1905, yet the total production in the former year was only half that in 1913.

The plants are located at Flint, Ripley (Houghton county), Sebewaing (Huron county), Rives Junction (Jackson county), Kalamazoo, Grand Rapids, Manistee, Menominee, Rochester (Oakland county), Holland, Saginaw, and Detroit.

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN, 1904-1913.

Year.	Number of operating plants.	Common brick.		Front brick.		Fancy brick.		Total value.
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
1904.....	10	9,886,000	\$64,034	580,000	\$5,234	19,000*	\$497	\$69,765
1905.....	12	24,841,000	155,883	1,577,000	12,893	24,000*	526	169,302
1906.....	13	27,561,000	165,879	1,704,000	12,892	24,700*	20	174,501
1907.....	13	25,488,000	158,606	2,000,000*	14,324	.....	.....	173,840
1908.....	10	21,997,000	138,897	1,900,000*	16,982	.....	.....	132,809
1909.....	11	24,317,000	207,082	1,600,000*	11,944	.....	.....	218,298
1910.....	10	27,448,337	218,637	3,258,800	22,022	.....	.....	240,649
1911.....	10	32,889,000	192,254	2,728,000	17,777	.....	.....	210,001
1912.....	11	45,129,000	307,166	1,168,000	9,626	.....	.....	316,732
1913.....	12	49,373,000	315,882	..... <sup>a</sup>	..... <sup>a</sup>	..... <sup>a</sup>	..... <sup>a</sup>	321,245
Grand total.....	.....	311,749,337	\$1,914,150	.....	.....	.....	.....	\$2,032,490

\*Estimated. (a) Included in total.

## MINERAL WATERS.

The production of mineral waters in Michigan is subject to large fluctuations from year to year, but since 1902 there has been a decrease from about 8,654,000 gallons to 885,000 gallons in 1913. The number of springs has not decreased in the same proportion, the number in 1913 being 20, or only 8 less than in 1902. Formerly the production and marketing of mineral water was conducted as an independent business, but now it is largely carried on in connection with other lines of business.

The great decrease in 1913 is chiefly due to the installation of new filtration plants at Grand Rapids and Marquette. The unsafe character of the municipal water supply of Grand Rapids for years past had given rise to a large industry in the vending of drinking water from springs and wells in the vicinity of the city. Similar conditions, though to a lesser degree, had prevailed at Marquette where the municipal supply from Lake Superior had been contaminated by the refuse from the wood kilns of the blast furnaces.

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1900-1913.

Year.	No. of springs.	Total.		Medicinal Value.	Table. Value.	Price per gal.
		Quantity. Gals.	Value.			
1900.....	28	3,398,996	\$411,935			
1901.....	28	7,019,168	1,195,614			
1902.....	28	8,653,690	275,763			
1903.....	19	6,919,107	200,668			
1904.....	19	3,385,675	118,422			
1905.....	17	2,684,800	277,188	\$38,900	\$238,288	\$ .10
1906.....	19	902,528	73,357			
1907.....	19	1,472,679	127,133	35,091	92,042	.09
1908.....	24	2,004,433	88,910	5,995	82,915	.04
1909.....	19	2,760,604	104,454	6,099	98,355	.04
1910.....	17	1,454,020	69,538	100	69,438	.05
1911.....	23	1,713,401	72,253	12,156	60,097	.04
1912.....	17	1,420,465	75,611	777	74,834	.053
1913.....	20	884,893	52,642	3,605	49,037	.059
Total...		44,674,459	3,143,488	\$96,723	\$765,006	

## NATURAL GAS.

Natural gas is produced chiefly in southeastern Michigan from drift wells drilled for water. The gas, associated with water, occurs in sand and gravel beds and apparently its source may be ascribed to leakage from bituminous and oil bearing strata which underlie the

drift in this portion of the state. The gas is usually in small volume and under small pressure. At Onkama, however, gas was struck in drift at a depth of about 437 feet under a pressure of 185 to 190 pounds per square inch. The gas wells generally last from 6 to 10 years but some "play out" in a few weeks or months, while others may last 20 years or more. When a well is exhausted, a new supply generally may be obtained by drilling deeper or sinking another well at some distance from the old one. Most of the gas wells are in Macomb and Oakland counties.

Considerable gas is associated with the oil in the Port Huron oil field and, in the Michigan Development Co. wells at Port Huron, it is sufficient to furnish motive power for pumping the wells.

PRODUCTION OF NATURAL GAS IN MICHIGAN, 1911-1913.

Year.	No. of producers.	Domestic.		Industrial.		Other.		Total.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		M. cu. ft.		M. cu. ft.		M. cu. ft.		M. cu. ft.	
1911...	22	930	\$930	900	\$450	800	\$400	1,730	\$1,330
1912...	17	.....	1,020	.....	.....	.....	.....	900	1,470
1913...	.....	.....	.....	.....	.....	.....	.....	1,805	1,405
Total..	.....	.....	.....	.....	.....	.....	.....	4,435	4,205

### PETROLEUM.

A small quantity of petroleum was produced in 1913 at Pt. Huron by the Michigan Development Co. The oil is a natural lubricant and is used by the G. B. Stock Xylite Grease and Oil Co. in the manufacture of lubricants for which the oil is especially adapted. The oil wells drilled at Saginaw in 1912 were abandoned in 1913 after producing a few hundred barrels of excellent oil.

### GRAPHITE.

Graphitic slate is quarried about 9 miles from L'Anse, Baraga county, by the Northern Graphite Works of L'Anse and the Detroit Graphite Co. of Detroit. The graphitic material is ground and utilized in the manufacture of paint. The mines were not operated in 1913, enough material having been mined in 1912 to supply the needs for 1913.

### QUARTZ.

Quartz is mined near Ishpeming by the Michigan Quartz Silica Co. of Milwaukee and ground chiefly for wood filler and paint. Some of the ground product is used for making polishes. The quartz is practically pure, containing 99.73% of silica with a trace of alumina, iron and calcium, and 0.27% of moisture.

### MINERAL PAINTS.

A considerable quantity of iron ore, mined in Iron county by Pickands, Mather & Co. is sold for metallic paint. The Acme White Lead & Color Co. of Detroit manufactures a large amount and a variety of mineral paints, but the two firms noted above are the only producers, hence statistics of production and value are not given.

## NONMETALLIC MINERALS.

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MICHIGAN COAL INDUSTRY.—STATISTICAL TABLES FOR 1913. COMPILED BY THE COMMISSIONER OF LABOR.

## January.

County.	Number of mines in operation.	Number of employees.	Average number of hours worked per day.	Average number of days worked per month.	Average daily wages.	Aggregate amount paid in wages.	Number of mines using powder.	Number of kegs of powder used.	Number of tons of coal mined.	Number of tons of coal mined.	Total number of tons of coal mined.	Total cost of out-put.	Average cost per ton.
Bay.....	8	1,204	7.5	20.3	\$3 44	\$90,522 28	8	1,633	32,982	23,074	55,956	\$119,589 05	\$2 13
Eaton.....	1	2	7	29	2 00	116 00	.....	.....	45	.....	45	67 50	1 50
Ingham.....	1	19	9	21	2 00	798 00	.....	.....	630	.....	630	1,165 50	1 85
Saginaw.....	11	1,063	7.6	17.7	3 30	62,205 64	11	1,791	21,867	26,801	47,168	93,676 54	1 98
Shiawassee.....	1	7	8	24	2 50	420 00	.....	.....	280	.....	280	280 00	1 00
Tuscola.....	1	116	8	14	3 15	5,115 60	1	136	2,327	775	3,102	7,537 86	2 43
Totals.....	23	2,505	7.5	18.9	\$3 36	\$159,177 52	20	3,550	57,531	49,650	107,181	\$222,316 55	\$2 07

## February.

Bay.....	8	1,201	7.5	16	\$3 53	\$68,923 38	8	1,016	25,009	18,984	43,943	\$93,283 36	\$2 12
Eaton.....	1	2	7	24	2 00	96 00	.....	.....	60	.....	60	80 00	1 33
Ingham.....	1	16	8	24	2 50	844 80	.....	.....	575	.....	575	1,063 75	1 85
Saginaw.....	11	1,072	7.6	18.2	3 53	68,983 72	11	1,743	24,975	26,865	51,860	94,641 00	1 82
Shiawassee.....	1	5	8	24	2 50	300 00	.....	.....	275	.....	275	275 00	1 00
Tuscola.....	1	96	8	13	3 21	4,006 08	1	102	2,171	723	2,894	6,974 54	2 41
Totals.....	23	2,392	7.6	16.9	\$3 54	\$143,153 98	20	2,861	53,065	46,542	99,607	\$196,733 07	\$1 97

## March.

Bay.....	8	1,186	7.5	14.3	\$3 75	\$63,647 37	8	915	19,444	20,782	40,608	\$83,958 19	\$2 08
Eaton.....	1	1	6	15	2 50	37 50	.....	.....	16	.....	16	24 60	1 50
Ingham.....	1	13	9	28	2 00	728 00	.....	.....	380	.....	380	793 00	1 85
Saginaw.....	9	882	7.5	19.6	3 24	56,033 66	9	1,296	18,581	22,027	40,608	77,869 69	1 91
Shiawassee.....	1	6	8	24	2 50	360 00	.....	.....	290	.....	290	290 00	1 00
Tuscola.....	1	101	8	12	3 24	3,926 88	.....	116	1,778	52	1,830	6,070 90	2 57
Totals.....	21	2,189	7.5	16.4	\$3 47	\$124,733 41	17	2,327	40,489	42,861	83,732	\$169,006 38	\$2 02

## MICHIGAN COAL INDUSTRY.—STATISTICAL TABLES.—Continued.

## April.

County.	No. of mines in operation.	No. of employees.	Average number of hours worked per day.	Average number of days worked per month.	Average daily wages.	Aggregate amount paid in wages.	Number of mines using powder.	Number of kegs of powder used.	Number of tons of picked coal mined.	Number of tons machine coal mined.	Total number of tons of coal mined.	Total cost of output.	Average cost per ton.
Bay.....	8	1,060	7.6	15.8	\$3 25	\$54,586 88	8	1,853	18,970	18,058	37,028	\$78,825 99	\$2 36
Ingham.....	1	10	8	14	2 00	280 00	.....	.....	195	.....	195	350 75	1 85
Saginaw.....	9	914	7.5	18.8	3 64	62,709 00	8	1,481	26,703	20,520	47,223	87,651 80	1 85
Shiawassee.....	1	8	8	24	2 50	480 00	.....	.....	300	.....	300	300 00	1 00
Tuscola.....	1	90	8	12	3 06	3,304 80	1	104	1,450	483	1,933	5,528 38	2 86
Totals.....	20	2,082	7.6	17	\$3 42	\$121,360 68	17	2,438	47,618	39,061	86,679	\$172,656 92	\$1 99

## May.

Bay.....	7	865	7.6	14	\$3 64	\$44,119 05	7	2,253	18,288	8,147	26,436	\$58,716 45	\$2 22
Ingham.....	1	15	8	21	2 00	210 00	.....	.....	103	.....	103	190 55	1 85
Saginaw.....	9	908	7.8	15.4	3 32	46,435 20	8	1,069	16,089	17,861	33,950	70,225 86	2 06
Shiawassee.....	1	5	8	24	2 50	200 00	.....	.....	275	.....	275	275 00	1 00
Tuscola.....	1	66	8	9	3 19	1,894 86	1	77	1,059	353	1,412	4,419 56	3 13
Totals.....	19	1,849	7.6	14.6	\$3 44	\$92,859 11	16	3,399	35,814	26,361	62,175	\$133,827 42	\$2 15

## June.

Bay.....	7	870	7.6	15.5	\$3 69	\$49,831 63	7	3,172	29,544	6,096	35,640	\$69,955 47	\$1 96
Ingham.....	1	2	8	21	2 00	84 00	.....	.....	51	.....	51	94 35	1 85
Saginaw.....	9	865	7.8	15.3	3 83	50,382 69	8	1,118	22,754	15,030	37,784	74,045 17	1 95
Shiawassee.....	1	10	8	24	3 00	720 00	.....	.....	400	.....	400	400 00	1 00
Tuscola.....	1	72	8	9	3 28	2,125 44	1	51	838	279	1,117	3,641 42	3 26
Totals.....	19	1,819	7.7	15.2	\$3 72	\$103,143 76	16	4,341	53,557	21,405	74,962	\$148,136 41	\$1 97

NONMETALLIC MINERALS.

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MICHIGAN COAL INDUSTRY.—STATISTICAL TABLES.—Continued.

July.

County.	No. of mines in operation.	No. of employees.	Average number hours worked per day.	Average number days worked per month.	Average daily wages.	Aggregate amount paid in wages.	Number of mines using powder.	Number of kegs of powder used.	Number of tons of picked coal mined.	Number of tons machine coal mined.	Total number of tons of coal mined.	Total cost of out-put.	Average cost per ton.
Bay.....	7	882	7.6	17.5	\$4 12	\$63,596 85	7	2,220	29,876	13,027	42,903	\$86,291 19	\$2 02
Ingham.....	1	4	9	26	2 10	210 60	.....	.....	80	.....	80	148 00	1 85
Saginaw.....	8	838	7.6	16.6	3 64	51,379 94	8	1,200	19,821	19,238	39,059	75,528 42	1 93
Shawasssee.....	1	8	8	24	3 00	576 00	.....	.....	350	.....	350	350 00	1 00
Tuscola.....	1	72	8	19	3 26	4,421 68	1	123	1,742	581	2,323	6,248 87	2 69
Totals.....	18	1,804	7.6	17.2	\$3 87	\$120,185 07	16	3,543	51,869	32,846	84,715	\$168,566 48	\$1 99

August.

Bay.....	8	1,023	7.6	21.9	\$3 41	\$77,158 83	8	1,555	23,465	28,840	52,305	\$105,038 00	\$2 00
Ingham.....	1	6	9	26	2 00	312 00	.....	.....	190	.....	190	351 50	1 85
Saginaw.....	7	800	7.6	19.9	3 59	57,140 74	7	1,260	18,283	24,214	42,497	81,319 91	1 91
Tuscola.....	1	75	8	26	3 30	6,435 00	1	179	2,745	915	3,660	8,088 60	2 21
Totals.....	17	1,913	7.6	21.2	\$3 48	\$141,064 57	16	3,014	44,683	53,969	98,652	\$194,798 10	\$1 97

September.

Bay.....	8	980	7.7	18.7	\$3 49	\$64,021 95	8	1,140	16,043	24,765	40,808	\$72,269 68	\$1 77
Ingham.....	1	6	9	26	2 65	413 40	.....	.....	210	.....	210	388 50	1 85
Jackson.....	1	2	8	12	2 00	48 00	.....	.....	54	.....	54	99 90	1 85
Saginaw.....	8	816	7.6	16.6	3 46	46,965 60	7	880	14,174	18,416	32,590	68,117 12	2 09
Tuscola.....	1	82	8	19	3 28	5,110 24	1	117	1,783	594	2,377	5,776 11	2 43
Totals.....	19	1,886	7.7	17.8	\$3 47	\$116,559 19	16	2,137	32,264	43,775	76,039	\$146,651 41	\$1 94



## MINERAL RESOURCES OF MICHIGAN.

## MICHIGAN COAL INDUSTRY.—STATISTICAL TABLES.—Concluded.

## October.

County.	Number of mines in operation.	Number of employees.	Average number hours worked per day.	Average number days worked per month.	Average daily wages.	Aggregate amount paid in wages.	Number of mines using powder.	Number of kegs of powder used.	Number of tons of picked coal mined.	Number of tons machine coal mined.	Total number of tons of coal mined.	Total cost of out-pit.	Average cost per ton.
Bay.....	9	1,175	7.5	25.1	\$3 45	\$101,838 28	9	1,661	25,453	41,888	67,341	\$133,801 24	\$1 99
Ingham.....	1	9	9	26	2 00	468 00	.....	.....	207	.....	207	382 95	1 85
Jackson.....	1	4	8	20	2 20	176 00	.....	.....	173	.....	173	320 05	1 85
Saginaw.....	1	867	7.6	24.4	3 11	66,673 19	.....	1,612	23,643	30,371	54,014	92,181 13	1 70
Tuscola.....	1	84	8	27	3 21	6,280 28	1	158	798	2,392	3,190	7,337 00	2 30
Totals.....	20	2,139	7.5	24.9	\$3 29	\$175,435 70	18	3,431	50,274	74,651	124,925	\$234,022 37	\$1 87

## November.

Bay.....	9	1,103	7.5	22.1	\$3 67	\$89,512 89	9	1,538	29,232	43,128	72,360	\$135,704 39	\$1 87
Calhoun.....	1	6	8	22	2 25	297 00	.....	.....	329	.....	329	608 65	1 85
Eaton.....	1	1	7	11	2 80	30 80	.....	.....	9	.....	9	20 00	2 22
Ingham.....	1	12	9	26	2 25	702 00	.....	.....	220	.....	220	407 00	1 85
Saginaw.....	7	825	7.6	21.7	3 16	56,684 55	7	1,241	21,495	20,976	42,471	80,726 89	1 94
Tuscola.....	1	72	8	19	3 21	4,391 28	1	122	1,895	631	2,526	6,264 48	2 48
Totals.....	20	2,019	7.5	21.4	\$3 50	\$151,618 52	17	2,901	53,180	64,735	117,915	\$223,731 41	\$1 89

## December.

Bay.....	7	1,165	7.9	20.8	\$3 73	\$90,563 64	8	1,238	15,214	48,562	63,796	\$136,563 50	\$1 98
Eaton.....	1	1	8	25	2 80	70 00	.....	.....	25	.....	25	50 00	2 00
Genesee.....	1	50	8	30	3 50	5,250 00	.....	.....	.....	124	124	2,145 65	17 30
Ingham.....	1	12	9	27	2 28	656 64	.....	.....	112	.....	112	715 07	6 37
Jackson.....	1	6	6	20	2 25	270 00	.....	.....	230	.....	230	414 00	1 80
Saginaw.....	8	922	7.9	22.6	3 40	70,804 83	8	1,448	22,410	30,244	52,654	96,704 39	1 84
Tuscola.....	2	155	8	25.5	3 28	12,835 76	2	348	3,893	1,723	5,116	13,228 60	2 58
Total.....	21	2,311	7.7	22	\$3 54	\$180,650 87	18	3,029	41,384	80,673	122,057	\$239,821 21	\$1 96

MICHIGAN COAL INDUSTRY.—STATISTICAL TABLES FOR 1913. COMPILED BY THE COMMISSIONER OF LABOR.  
SUMMARY.

County.	No. of mines in operation.	No. of employees.	Average number of hours worked per day.	Average number days worked per month.	Average daily wages.	Aggregate amount paid in wages.	Number of mines using powder.	Number of kegs of powder used.	Number of tons of picked coal mined.	Number of tons of machine coal mined.	Total number of tons of coal mined.	Total cost of out-pur.	Average cost per ton.
January.....	23	2,505	7.6	18.9	\$3.36	\$159,177.52	20	3,550	57,531	49,650	107,181	\$222,316.55	\$2.07
February.....	23	2,332	7.6	16.9	3.54	143,153.95	20	2,851	53,065	46,542	99,607	196,733.07	1.97
March.....	21	2,189	7.5	16.4	3.47	124,133.41	17	2,327	40,489	42,861	83,350	169,006.38	2.02
April.....	20	2,082	7.6	17	3.42	121,860.65	17	2,438	47,618	39,061	86,679	172,656.92	1.99
May.....	19	1,849	7.6	14.6	3.44	92,859.11	16	3,399	35,814	26,361	62,175	133,827.42	2.15
June.....	19	1,819	7.6	15.2	3.72	103,143.76	16	3,341	53,557	21,405	74,962	148,136.41	1.97
July.....	18	1,804	7.6	17.2	3.67	120,185.97	16	3,343	51,869	32,846	84,715	168,566.46	1.99
August.....	17	1,913	7.6	21.2	3.45	141,094.57	16	3,017	44,683	53,999	98,682	194,798.10	1.97
September.....	19	1,886	7.7	17.8	3.47	119,639.19	16	2,137	32,264	43,776	76,039	146,651.41	1.94
October.....	20	2,136	7.5	24.9	3.29	175,438.10	19	2,431	50,274	74,651	124,925	234,022.37	1.87
November.....	20	2,019	7.5	21.4	3.50	151,618.52	17	2,901	53,180	64,735	117,915	223,731.41	1.89
December.....	21	2,311	7.7	22.0	3.64	180,650.87	18	3,029	41,384	60,673	122,057	239,821.21	1.96
Totals for year.....	.....	.....	.....	.....	.....	\$1,629,942.38	.....	36,971	561,728	576,529	1,138,639	\$2,260,267.73	.....
Averages.....	20	2,075	7.6	18.7	\$3.40	.....	18	.....	.....	.....	.....	.....	\$1.97

NONMETALLIC MINERALS.

## MINERAL RESOURCES OF MICHIGAN.

## PRODUCTION OF COAL BY COUNTIES, 1899-1913.

	Bay.	Eaton.	Ingham.	Jackson.	Saginaw.	Shia- wassee.	Tuscola.	Other counties.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
*1913..	579,123	155	2,953	457	521,848	2,170	31,480	453
*1912..	607,740	374	3,874	.....	489,198	4,532	59,252	.....
1911...	766,470	100	.....	.....	667,282	13,000	66,427	19,000
1910...	766,470	100	.....	.....	667,282	.....	.....	101,215
1909...	822,577	558	.....	1,500	859,434	.....	.....	100,623
1908...	782,503	2,286	.....	5,539	999,338	.....	.....	45,353
1907...	962,574	5,982	.....	5,645	1,047,927	.....	.....	13,730
1906...	481,398	18,507	.....	8,658	835,475	.....	.....	2,300
1905...	544,154	4,058	.....	9,196	915,803	.....	.....	.....
1904...	410,634	9,057	.....	16,860	906,289	.....	.....	.....
1903...	325,021	7,393	.....	23,307	1,011,898	.....	.....	.....
1902...	248,645	8,800	.....	23,889	670,304	.....	.....	13,400
1901...	253,821	4,803	.....	20,288	938,042	.....	.....	24,284
1900...	190,814	4,530	.....	23,317	601,112	.....	.....	.....
1899...	104,588	3,421	.....	21,600	455,607	.....	.....	39,492

\*Compiled from Annual Report of State Department of Labor.

NONMETALLIC MINERALS.

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PRODUCTION OF COAL IN MICHIGAN, 1860-1913, IN SHORT TONS.

Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.
1860.....	2,320	1871.....	32,000	1882.....	135,339	1893.....	45,979	1904.....	1,342,840
1861.....	3,000	1872.....	33,600	1883.....	71,296	1894.....	70,022	1905.....	1,473,211
1862.....	5,000	1873.....	56,000	1884.....	36,712	1895.....	112,322	1906.....	1,346,338
1863.....	8,000	1874.....	58,000	1885.....	45,178	1896.....	92,882	1907.....	2,035,858
1864.....	12,000	1875.....	62,500	1886.....	60,434	1897.....	223,592	1908.....	1,835,019
1865.....	15,000	1876.....	66,000	1887.....	71,461	1898.....	315,722	1909.....	1,784,692
1866.....	20,000	1877.....	69,197	1888.....	81,407	1899.....	624,708	1910.....	1,534,967
1867.....	25,000	1878.....	85,322	1889.....	67,431	1900.....	849,475	1911.....	1,476,074
1868.....	28,000	1879.....	82,015	1890.....	74,977	1901.....	1,241,241	1912.....	1,164,973
1869.....	29,980	1880.....	100,800	1891.....	80,307	1902.....	964,718	1913.....	1,138,639
1870.....	28,150	1881.....	112,000	1892.....	77,990	1903.....	1,367,619	Total.....	22,777,307

SUMMARY TABLE OF THE PRODUCTION AND VALUE OF THE MINERAL PRODUCTS OF MICHIGAN IN 1913.

	Quantity.	Value.
Brick and tile products, number of brick . . . . .	282,664,000	\$2,451,242
Brick-sand lime, number of brick . . . . .	50,065,000	321,245
Bromine . . . . .		a
Calcium chloride . . . . .		a
Portland cement, bbls made, value cement shipped . . . . .	4,186,236	4,228,879
Clay, tons . . . . .	1,710	6,504
Coal, tons . . . . .	1,138,639	b2,250,267
Coke . . . . .		a
Copper, lbs . . . . .	183,501,973	28,442,806
Grindstones . . . . .		a
Gypsum and gypsum products, tons mined . . . . .	423,896	721,325
*Iron ore, long tons . . . . .	12,677,466	31,947,214
Iron—pig, long tons made, value pig iron shipped . . . . .	447,188	6,568,920
Lime, tons made . . . . .	77,088	331,852
Limestone . . . . .		1,408,703
Mineral paints . . . . .		a
Mineral waters, gallons . . . . .	884,893	52,642
Natural gas, M. cu. ft. . . . .	1,805	1,405
Petroleum . . . . .		a
Pottery . . . . .		222,133
Quartz . . . . .		a
**Salt, bbls . . . . .	11,528,800	3,293,032
Sand and gravel, tons . . . . .	6,422,818	1,528,892
Sandstone . . . . .		19,224
Silver . . . . .		
Trap-rock . . . . .		92,201
Miscellaneous . . . . .		2,589,580
Grand total . . . . .		\$86,478,066

\*Tonnage given by Iron Trade Review.

\*\*Includes rock salt but not bromine or calcium chloride.

(a) Included under miscellaneous.

(b) Cost of production.

# DIRECTORY OF MINERAL PRODUCERS OF MICHIGAN FOR 1913.

## BRICK AND TILE MANUFACTURERS, 1913.

Operators.	Office.	Works.
<i>Allegan County:</i>		
Allegan Brick Works.....	Allegan.....	Allegan.
Cady, L. Y.....	Allegan.....	Allegan.
Zeeland Brick Co.....	Zeeland.....	Zeeland.
<i>Barry County:</i>		
Leonard, Wm.....	Delton.....	Delton.
<i>Bay County:</i>		
Michigan Vitrified Brick Co.....	Bay City.....	Bay City.
<i>Berrien County:</i>		
Mamer Brick Co.....	Benton Harbor.....	Benton Harbor.
<i>Branch County:</i>		
Reynolds & Son, Lorenzo D.....	Quincy.....	Algansee.
<i>Charlevoix County:</i>		
Boyne City Brick Co.....	Boyne City.....	Boyne City.
East Jordan Clay Products Co.....	East Jordan.....	East Jordan.
<i>Chippewa County:</i>		
Rudyard Brick Works.....	Rudyard.....	Rudyard.
<i>Dickinson County:</i>		
Vulcan Brick Works.....	Vulcan.....	Vulcan.
<i>Eaton County:</i>		
American Sewer Pipe Co.....	Broad St., Akron, Ohio....	Grand Ledge, Mich.
Grand Ledge Clay Products Co.....	Grand Ledge.....	Grand Ledge.
<i>Emmet County:</i>		
Dearment, C. A.....	Petoskey.....	Petoskey.
<i>Genesee County:</i>		
Gale Bros.....	Atlas.....	Atlas.
Oloff, Thomas.....	Clio.....	Clio.
Uptegraff & Co., W. H.....	Davison.....	Davison.
Duffield Brick & Tile Works.....	Duffield.....	Duffield.
McCann, Fred'k W.....	Gaines.....	Gaines.
Otter Lake Brick & Tile Co.....	Otter Lake.....	Otter Lake.
Sharp, Frank.....	R. D. No. 1, Linden.....	South Mundy.
<i>Gladwin County:</i>		
Korkoske, Christ.....	Gladwin.....	Gladwin.
<i>Gratiot County:</i>		
Ashley Tile Co.....	Ashley.....	Ashley.
Stevenson & Sons, David.....	Ashley.....	Ashley.
Ithaca Brick & Tile Yards.....	Ithaca.....	Ithaca.
Lee, Chas.....	North Star.....	North Star.
Peet, C. D.....	North Star.....	North Star.
Smith & Sons, Wm. H. H.....	St. Louis.....	St. Louis.
Riverside Brick & Tile Co.....	Sumner.....	Sumner.
<i>Hillsdale County:</i>		
Jerome Brick & Tile Co.....	Jerome.....	Jerome.
Gish & Connor.....	Waldron.....	Waldron.
<i>Ingham County:</i>		
Clippert, Spaulding & Co.....	Lansing.....	Lansing.

## BRICK AND TILE MANUFACTURERS, 1913.—Continued.

Operators.	Office.	Works.
<i>Ionia County:</i>		
Brown, Albert .....	Saranac .....	Saranac.
Van Der Heyden, Fred H. ....	Ionia .....	Ionia.
<i>Isabella County:</i>		
Kane Bros. ....	Mt. Pleasant .....	Mt. Pleasant.
Thompson & Son, T. ....	Mt. Pleasant .....	Mt. Pleasant.
<i>Jackson County:</i>		
Simpson, Nathan F., Warden Michigan State Prison .....	Jackson .....	Jackson.
American Sewer Pipe Co. ....	Akron, Ohio .....	Jackson.
<i>Kalamazoo County:</i>		
Zeeland Brick Co. ....	Zeeland .....	Brownell.
<i>Kent County:</i>		
Grand Rapids Brick Co. ....	Mich. Ave. and Fuller St. ....	Grand Rapids.
Sparta Clay Works. ....	Grand Rapids .....	Sparta.
<i>Lenawee County:</i>		
Laurenson & Saunders .....	Addison .....	Addison.
Wilt, C. H. ....	Blissfield .....	Blissfield.
Britton Pressed Brick Co. ....	Ann Arbor .....	Britton.
Atkin, Wm. T. ....	Deerfield .....	Deerfield.
Woodford & Son, B. F. ....	Jasper .....	Jasper.
Ellis, G. D. ....	Macon .....	Macon.
American Brick & Tile Co. ....	Morenci .....	Morenci.
Morenci Brick & Tile Works .....	Morenci .....	Morenci.
Comfort, Albert A. ....	R. D., Tecumseh .....	Tecumseh.
<i>Macomb County:</i>		
Hartsig, Jacob .....	Warren .....	Centerline.
Hacker, Frank G. ....	Mt. Clemens .....	Clinton.
Gass, East. ....	R. D. No. 2, Washington .....	Davis.
Mt. Clemens Brick & Tile Co. ....	Mt. Clemens .....	Mt. Clemens.
Warren Brick & Tile Works .....	Warren .....	Warren.
<i>Manistee County:</i>		
Kujawski, Joseph .....	Oakhill .....	Oakhill.
<i>Macosta County:</i>		
Nehmer, Wm. F. ....	Big Rapids .....	Big Rapids.
<i>Midland County:</i>		
Rilett, J. W. ....	R. D. No. 3, Coleman .....	Coleman.
Midland Brick & Tile Co. ....	Midland .....	Midland.
<i>Monroe County:</i>		
Meyer Bros. ....	Azalia .....	Azalia.
Linenfelter Brick & Tile Co. ....	Maybee .....	Maybee.
Angerer Clay Products Co. ....	Scofield .....	Scofield.
Strong & Son, John .....	South Rockwood .....	South Rockwood.
<i>Muskegon County:</i>		
Holton Brick Co. ....	Muskegon .....	Holton.
<i>Newaygo County:</i>		
Schrier & Stevens .....	R. D., Grant .....	Grant.
<i>Ottawa County:</i>		
Zeeland Brick Co. ....	Zeeland .....	Zeeland.
<i>Saginaw County:</i>		
Parker-Lohmann Brick & Tile Co. ....	R. D. No. 10, Saginaw, W. S. ....	Saginaw, W. S.
Robie, Mrs. Peter .....	R. D. No. 10, Saginaw, W. S. ....	Paines.
Sperry Bros. ....	Paines .....	Paines.
Day, James .....	R. D. No. 8, Saginaw .....	Saginaw.
Day, Thomas .....	R. D. No. 3, Saginaw .....	Saginaw.
Saginaw Paving Brick Co. ....	1850 S. Jefferson Ave., Saginaw .....	Saginaw.

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## SAND-LIME BRICK PRODUCERS, 1913.

Operators.	Office.	Works.
<i>Genesee County:</i> Flint Sandstone Brick Co.....	Flint.....	Flint.
<i>Houghton County:</i> Lake Superior Stone Brick Co.....	Calumet.....	Ripley.
<i>Huron County:</i> Sebewaing Sandstone Brick Co.....	Sebewaing.....	Sebewaing.
<i>Jackson County:</i> Jackson-Lansing Brick Co.....	Rives Junction.....	Rives Junction.
<i>Kalamazoo County:</i> South Michigan Brick Co.....	Kalamazoo.....	Kalamazoo.
<i>Kent County:</i> Grande Brick Co.....	Kalamazoo Ave., Grand Rapids.....	Grand Rapids.
<i>Manistee County:</i> Manistee Brick Co.....	Manistee.....	Manistee.
<i>Menominee County:</i> Menominee Brick Co.....	Menominee.....	Menominee.
<i>Oakland County:</i> Rochester Brick & Sand Co.....	Rochester.....	Rochester.
<i>Ottawa County:</i> Holland Pressed Brick Co.....	Holland.....	Holland.
<i>Saginaw County:</i> Saginaw Brick Co.....	321 N. Hamilton St., Saginaw.....	Saginaw.
<i>Wayne County:</i> Michigan Pressed Brick Co.....	Cor. Lawton Ave. and M. C. R. R., Detroit.....	Detroit.
Church Brick Co.....	Sibley.....	Sibley.

## CEMENT PRODUCERS, 1913.

Operators.	Office.	Works.
Huron Portland Cement Co.....	1525 Ford Bldg., Detroit.	Alpena.
Burt Portland Cement Co.....	Bellevue.....	Bellevue.
Peninsular Portland Cement Co.....	Cooley Block, Jackson....	Cement City.
Michigan Portland Cement Co.....	Chelsea.....	Four Mile Lake.
Wolverine Portland Cement Co.....	Coldwater.....	Coldwater and Quincy.
New Aetna Portland Cement Co.....	412 Union Trust Bldg., Detroit.....	Fenton.
Omega Portland Cement Co.....	Jonesville.....	Mosherville.
Newaygo Portland Cement Co.....	Grand Rapids.....	Newaygo.
Peerless Portland Cement Co.....	Union City.....	Union City.
Wyandotte Portland Cement Co.....	1525 Ford Bldg., Detroit.	Wyandotte.

## CLAY MINERS, 1913.

Operators.	Office.	Mine.
<i>Ontonagon County:</i>		
Emmond, Wm. F.....	Rockland.....	Rockland.
Robinson Clay Products Co.....	1010 E. Market St., Akron, Ohio.....	Rockland.
Vogtlin, W. P.....	Rockland.....	Rockland.
<i>Wexford County:</i>		
Stanley & Son, J. Z.....	Harriette.....	Harriette.

## MICHIGAN COAL MINES IN 1913.

Operator.	Office.	Mine.	Location.	General Manager.
<i>Bay County:</i> Handy Bros. Mining Co. Michigan Vitrified Brick Co. Republic Coal Co. (Robt. Gage Coal Co.) Robert Gage Coal Co. Robert Gage Coal Co. Robert Gage Coal Co.	Bay City, W. S. Bay City, W. S. Bay City, E. S. Bay City, E. S. Bay City, E. S. Bay City, E. S.	Monitor. Beaver. Robt. Gage No. 5. Robt. Gage No. 6. Black Diamond or Robt. Gage No. 7.	Monitor Twp., S. W. 1, N. W. 1, Sec. 22. Frankenlust Twp., N. E. 1, Sec. 1. Frankenlust Twp., N. W. 1, S. E. 1, Sec. 2. Monitor Twp., S. W. 1, N. E. 1, Sec. 19. Monitor Twp., S. W. 1, S. E. 1, Sec. 18. Monitor Twp., N. E. 1, S. E. 1, Sec. 30.	T. L. Handy. J. Barnett. Chas. Coryell. Chas. Coryell. Chas. Coryell. Chas. Coryell.
Royal Coal Co. What Cheer Coal Co. Wolverine Coal Co., (Consolidated Coal Co.) Wolverine Coal Co., (Consolidated Coal Co.)	Bay City, W. S. Bay City. Saginaw. Saginaw.	Royal. What Cheer. Wolverine No. 2. Wolverine No. 3.	Bay City, W. S. Merritt Twp., Sec. 30. Monitor Twp., S. W. 1, S. E. 1, Sec. 17. Williams Twp., S. E. 1, N. E. 1, Sec. 12.	Chas. Coryell. Jos. Bierd. E. B. Foss. R. M. Randall. R. M. Randall.
<i>Calhoun County:</i> Jackson Coal Co.	Albion.	Albion.	Four miles N. of Albion.	T. M. Jenkins.
<i>Eaton County:</i> H. D. Pickens. M. D. Sattler. Eben Wright.	Grand Ledge. Grand Ledge. Grand Ledge.	Pickens. Sattler. Wright.	Grand Ledge. Grand Ledge. Grand Ledge.	H. D. Pickens. M. D. Sattler. E. Wright.
<i>Genesee County:</i> Genesee Coal Co. What Cheer Coal Co.	Flint. Bay City.	Genesee No. 2. What Cheer No. 2.	Flint. Flint.	DeVere Hall. E. B. Foss.
<i>Ingham County:</i> Cedar River Coal Co.	Williamston.	Cedar River.	Williamston.	T. M. Jenkins.
<i>Saginaw County:</i> Banner Coal Co. Bliss Coal Co. Caledonia Coal Mining Co. Carbon Coal Co. Consolidated Coal Co.	Swan Creek. Swan Creek. Saginaw. Saginaw. Saginaw.	Banner. Swan Creek. Caledonia No. 3. Verne or Carbon Chappel & Fordney No. 2.	James Twp., N. E. 1, S. W. 1, Sec. 12. James Twp., S. E. 1, S. W. 1, Sec. 11. Saginaw Twp., S. E. 1, Sec. 21. Saginaw, E. S. Saginaw Twp., S. E. 1, N. E. 1, Sec. 33. Saginaw Twp., S. W. 1, N. E. 1, Sec. 7. James Twp., S. W. 1, N. E. 1, Sec. 4. Saginaw Twp., S. N. E. 1, N. E. 1, Sec. 3. St. Charles Twp., N. E. 1, N. E. 1, Sec. 17.	W. B. Carmichael. C. E. Linton. John Dagan. E. Savage. R. M. Randall. R. M. Randall. R. M. Randall. R. M. Randall. R. M. Randall. Chas. Coryell.
Consolidated Coal Co. Juntown Coal Co., (Consolidated Coal Co.) Riverside Coal Co., (Consolidated Coal Co.) Riverside Coal Co., (Consolidated Coal Co.) Robt. Gage Coal Co.	Saginaw. Saginaw. Saginaw. Saginaw. Bay City.	P. Marquette No. 3. Juntown or Northern Riverside No. Riverside No. 2. No. 2 (Old)		

MICHIGAN COAL MINES IN 1913.—*Concluded.*

Operator.	Office.	Mine.	Location.	General Manager.
<i>Saginaw County.—Concluded.</i>				
Robt. Gage Coal Co.	Bay City	No. 2 (New)	St. Charles Twp., N. E. $\frac{1}{4}$ , S. W. $\frac{1}{4}$ , Sec. 9	Chas. Coryell.
Robt. Gage Coal Co.	Bay City	No. 3	St. Charles Twp., S. E. $\frac{1}{4}$ , N. W. $\frac{1}{4}$ , Sec. 17	Chas. Coryell.
Saginaw Coal Co. (Consolidated Coal Co.)	Saginaw	Saginaw Old Mine	Buena Vista Twp., N. E. $\frac{1}{4}$ , Sec. 31	R. M. Randall.
Shiawassee Coal Co. (Consolidated Coal Co.)	Saginaw	Shiawassee	James Twp., S. E. $\frac{1}{4}$ , S. W. $\frac{1}{4}$ , Sec. 8	R. M. Randall.
Uncle Henry Coal Co. (Consolidated Coal Co.)	Saginaw	Uncle Henry	Blumfield Twp., N. W. $\frac{1}{4}$ , Sec. 18	R. M. Randall.
<i>Shiawassee County:</i>				
Corunna Union Coal Co.	Corunna	Union Mine	Corunna	W. F. Striggon.
Detroit Vibrated Brick Co.	Detroit	Peak	Corunna	F. Schmidt.
Nond-Kean Coal Mining Co.			Owosso	J. J. Kean.
<i>Tuscola County:</i>				
Handy Bros. Mining Co.	Bay City, W. S.	Akron No. 1	Fairgrove Twp., N. W. $\frac{1}{4}$ , N. W. $\frac{1}{4}$	T. L. Handy.

## COKE PRODUCERS, 1913.

Operators.	Address.	Location of plant.	No. of ovens.	County.
Michigan Alkali Co. ....	Wyandotte. ....	Plant No. 2. ....	30	Wayne.
Semet-Solvay Co. ....	Syracuse, N. Y. ....	Detroit. ....	172	Wayne.

## NATURAL GAS PRODUCERS, 1913.

Operator.	Address.
<i>Bensie County:</i> Rqwe, Clarence L. ....	Beulah.
<i>Hillsdale County:</i> DeWitt, C. M. ....	Osseo.
<i>Macomb County:</i> Dobberowsky, John. .... Hanekow, Mrs. Wm. H. .... Hartsig, Wm. L. .... Jacobs, Edward and Otto. .... Martin, Henry. .... Mielke, August. .... Peters, Alfred R. .... Smith, Alex. .... Vohs, Henry and John. .... Wolgast, Max. ....	Halfway. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2. Warren, R. F. D. No. 2.
<i>Oakland County:</i> Granzow, Louis. .... Landau, Ed. .... Langer, Henry. .... Parmenter, Frank. .... Purdy, Wm. J. .... Springsteen, N. E. ....	Royal Oak, R. D. Royal Oak, R. D. Royal Oak. Royal Oak. Redford, R. F. D. No. 1. Royal Oak.
<i>St. Clair County:</i> Haas, H. O. .... Michigan Central Oil, Gas and Mineral Co. .... Michigan Development Co. .... Ruff, J. F. .... Stevens, H. Leroy. .... Stock Co., G. B., Xylite Grease and Oil Co. ....	Port Huron. Port Huron. Port Huron. Port Huron. Port Huron. Port Huron.
<i>Washtenaw County:</i> Harmon, H. E. ....	Willis.
<i>Wayne County:</i> Becker, Irving. ....	Redford.

## GRINDSTONE AND SCYTHESTONE PRODUCERS, 1913.

Operator.	Office.	Quarry.
<i>Huron County:</i> Cleveland Stone Co. .... The Wallace Co. .... Cleveland Stone Co. ....	Cleveland, Ohio. .... Port Austin. .... Cleveland, Ohio. ....	Grindstone City. Grindstone City. Port Austin.

MINERAL PRODUCERS OF MICHIGAN.

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PRODUCERS OF GYPSUM PRODUCTS, 1913.

Operator.	Office.	Name of plant.	Location of mine.
United States Gypsum Co.....	Chicago, Ill.....	Alabaster.....	Alabaster.
United States Gypsum Co.....	Chicago, Ill.....	Midland.....	Grand Rapids.
Acme Cement Plaster Co.....	St. Louis, Mo.....	Mill No. 5.....	Beverly.
Michigan Gypsum Co.....	Grand Rapids.....	.....	Grand Rapids.
American Cement Plaster Co.....	Lawrence, Kas.....	Grand Rapids...	Grand Rapids.
Grand Rapids Plaster Co.....	427 Mich. Trust Bldg., Gd. Rapids.	Eagle Mill.....	Grand Rapids.
		Grandville.....	Grandville.

PIG IRON PRODUCERS, 1913.

Operator.	Office.	Name of furnace.	Location of furnace.
Lake Superior Iron & Chemical Co.....	Detroit.....	Boyne City...	Boyne City.
Lake Superior Iron & Chemical Co.....	Detroit.....	Chocolay.....	Chocolay.
Lake Superior Iron & Chemical Co.....	Detroit.....	Elk Rapids.....	Elk Rapids.
Lake Superior Iron & Chemical Co.....	Detroit.....	Manistique.....	Manistique.
Lake Superior Iron & Chemical Co.....	Detroit.....	Newberry.....	Newberry.
Mitchell-Diggins Iron Co.....	Cadillac.....	Cadillac.....	Cadillac.
Detroit Furnace Co.....	1069 Jefferson Ave., Detroit..	Detroit.....	Detroit.
Detroit Iron & Steel Co.....	149 Jefferson Ave., Detroit..	A & B.....	Detroit.
East Jordan Furnace Co.....	East Jordan.....	.....	East Jordan.
Spring Lake Iron Co.....	Fruitport.....	Fruitport.....	Fruitport.
Cleveland Cliffs Iron Co.....	Cleveland, Ohio.	Pioneer No. 1.	Gladstone.
Jones, John T.....	Iron Mountain..	Ardis.....	Iron Mountain.
Jones, John T.....	Iron Mountain..	Kloman.....	Republic.
Antrim Iron Co.....	Antrim.....	Antrim.....	Antrim.
Pioneer Iron Co.....	.....	Carp.....	Near Marquette.
Pioneer Iron Co.....	.....	Pioneer No. 2.	Near Marquette.
Stevenson Charcoal Iron Co.....	.....	Stevenson.....	Wells.

## LIMESTONE AND LIME PRODUCERS, 1913.

Operators.	Office.	Quarry.
<i>Alpena County:</i> Collins, R. (also lime).....	151 Water St., Alpena.....	Alpena.
Michigan Alkali Co.....	Wyandotte.....	Wyandotte.
<i>Arenac County:</i> McDonnell, Jas. (lime).....	Twining.....	Omer.
<i>Charlevoix County:</i> Northern Lime Co. (lime).....	Petoskey.....	Bay Shore.
Charlevoix Rock Products Co. (also lime).....	Charlevoix.....	Charlevoix.
<i>Cheboygan County:</i> Campbell Stone Co. (also lime)...	Indian River.....	Afton.
<i>Delta County:</i> Delta Contracting Co.....	Escanaba.....	Escanaba (Hyde.)
Bichler, John.....	Groos.....	
<i>Emmet County:</i> Antrim Lime Co. (also lime)....	912 Mich. Trust Bldg., Grand Rapids.....	Petoskey.
Northern Lime Co. (also lime)....	Petoskey.....	Petoskey.
Petoskey Crushed Stone Co.....	Petoskey.....	Petoskey.
<i>Huron County:</i> The Wallace Stone Co.....	Bay Port.....	Bay Port.
<i>Mackinac County:</i> Ozark Stone Quarry.....	Ozark.....	Ozark.
Union Carbide Co.....	42nd St. Bldg., New York, N. Y.	Hendrick's Quarry.
Fiborn Limestone Co.....	Sault Ste. Marie, Ontario, Can..	Fiborn Quarry.
<i>Marquette County:</i> City of Negaunee.....	Negaunee.....	
<i>Menominee County:</i> Menominee Stone Crusher.....	Menominee.....	Menominee.
<i>Monroe County:</i> Shore Line Stone Co.....	Monroe.....	Frenchtown.
The France Stone Co.....	1800 Second Nat'l Bank Bldg., Toledo, O.....	Monroe.
<i>Presque Isle County:</i> Michigan Limestone & Chemical Co.....	55 Liberty St., New York, or Rogers City, Mich.....	Calcite.
<i>Schoolcraft County:</i> The White Marble Lime Co.....	Manistique..... (Also lime)....	Blaney, Manistique and Marblehead.
Delta Contracting Co.....	Escanaba.....	Manistique.
<i>Wayne County:</i> Solvay Process Co.....	Syracuse, N. Y.....	Trenton and Sibley.

## MINERAL PAINT PRODUCERS, 1913.

Pigment.	Operator.	Office.	Location of plant.
Met. paint.....	Huron Valley Consoli- dated Paint & Oil Co..	Ypsilanti.....	Belleville.
White lead, red lead, litharge orange mineral.....	Acme White Lead & Color Works.....	Detroit.....	Detroit
Met. Paint.....	Pickands, Mather & Co..	Cleveland, Ohio..	Iron County.

# MINERAL PRODUCERS OF MICHIGAN.

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## MINERAL WATER PRODUCERS, 1913.

Operators.	Office.	Spring.
Arctic Spring Water Co.....	412 Ottawa Ave., Grand Rapids.....	Arctic.
Bailey Marvel Springs Co.....	Bellaire.....	Alden.
Willis, J. L.....	Bangor.....	Beaver.
Bromo-Hygeia Mineral Water Co.....	Coldwater.....	Bromo-Hygeia.
Charlevoix Mineral Water Co.....	Charlevoix.....	
Walker Gordon Farm & Laboratory Co.....	Birmingham.....	Cooper Farm Spring.
Crystal Spring Water, Fuel & Ice Co..	35 No. Division St., Grand Rapids.....	Crystal Spring.
Eastman Springs Co.....	Benton Harbor.....	Eastman.
Detroit Mineral Water Co.....	584 Michigan Ave., Detroit.....	Giant Spring.
Harrison Spring Water Co.....	360 W. Bridge St., Grand Rapids.....	Harrison.
Polaris Water Co.....	Marquette.....	Lake Superior Mineral Spring.
Mt. Clemens Crystal Springs Water Co.	Mt. Clemens.....	Mt. Clemens Crystal Spring.
Ogemaw Spring Water Co.....	Bay City.....	Ogemaw.
Dewitt, C. M.....	Osseo.....	Osseo.
Ponce de Leon Co.....	Grand Rapids.....	Ponce de Leon.
Pike, Lute H.....	Topinabee.....	Sautas.
Shorkey, Chas.....	Mt. Clemens.....	Victory.
Coca-Cola Bottling Co.....	Battle Creek.....	White Oak.
Ypsilanti Mineral Water & Bath Co..	Ypsilanti.....	Moorman Well.

## PETROLEUM PRODUCERS, 1913.

Operators.	Address.
Michigan Development Co.....	103 Huron Ave., Port Huron.
Stock Xylite Grease & Oil Co., G. B.....	Port Huron.

## POTTERY PRODUCERS, 1913.

Operator.	Office.	Works.
<i>Ionia County:</i> Ionia Pottery Co.....	Ionia.....	Ionia.
<i>Wayne County:</i> Detroit Flower Pot Co.....	490 Howard St., Detroit.....	Detroit.
Jeffery-Dewitt Co.....	Detroit.....	Detroit.
Hupprich, Anton.....	2161 Michigan Ave., Detroit.....	Detroit.
Fewabic Pottery & Tile Co.....	2161 Jefferson St., Detroit.....	Detroit.

## QUARTZ PRODUCERS, 1913.

Operator.	Office.	Mine.
<i>Marquette County:</i> Michigan Quartz Silica Co.....	Milwaukee, Wis.....	Ishpeming.



## SALT PRODUCERS, 1913.

Operators.	Office.	Works.
<i>Bay County:</i> Hine Lumber Co. ....	Sta. A., Bay City.....	W. Bay City.
<i>Isabella County:</i> Van Schaack & Sons, Peter.....	118 Lake St., Chicago, Ill. ....	Mt. Pleasant.
<i>Manistee County:</i> Peters Salt & Lumber Co., R. G.... Flier & Sons, Vacuum Pan Salt Wks. The Buckley & Douglass Lumber Co. Sands Salt & Lumber Co., Louis....	East Lake..... Flier City..... 381 River St., Manistee..... Manistee.....	East Lake. Flier City. Manistee. Manistee.
<i>Mason County:</i> Anchor Salt Co..... Stearns Salt & Lumber Co.....	Ludington..... Ludington.....	Ludington. Ludington.
<i>Midland County:</i> The Dow Chemical Co.....	Midland.	
<i>Saginaw County:</i> Mershon, Eddy, Parker & Co..... Bliss & Van Auken Lumber Co..... Eastman Flooring Co., S. L..... Germain, Edward.....  Saginaw Plate Glass Co..... Saginaw Salt Co.....	Saginaw..... Saginaw, W. S..... Saginaw, W. S..... Holland Ave. near Genesee St., Saginaw, E. S..... Saginaw, W. S..... 430 Shearer Bldg., Bay City.....	Carrollton. Saginaw. Saginaw. Saginaw. Saginaw. Saginaw. St. Charles.
<i>St. Clair County:</i> Davidson-Wonsey Co..... Michigan Salt Works..... Morton Salt Co..... Diamond Crystal Salt Co.....	Marine City..... Marine City..... 717 Ry. Ex., Chicago, Ill..... St. Clair.....	Marine City. Marine City. Port Huron. Port Huron.
<i>Wayne County:</i> Delray Salt Co..... Solvay Process Co..... Detroit Rock Salt Co..... Mulkey Salt Co..... Kay Salt Co..... Peninsular Salt Co..... Worcester Salt Co..... Michigan Alkali Co..... Pennsylvania Salt Mfg. Co.....	Detroit..... Detroit..... Scranton, Pa..... 610 Equity Bldg., Detroit..... Charleston, W. Va..... Ecorse. 168 Duane St., New York, N. Y..... Wyandotte..... 115 Chestnut St., Philadelphia, Pa.	Delray. Delray. Detroit. Ecorse. Ecorse. Wyandotte. Wyandotte.

## SAND AND GRAVEL PRODUCERS IN MICHIGAN FOR 1913.

Nineteen hundred operators. See directory, Mineral Resources of Michigan for 1912, Publication 13, Geological Series 10, pp. 204-243.

## SANDSTONE PRODUCERS, 1913.

Operator.	Office.	Quarry.
<i>Houghton County:</i> Portage Entry Redstone Co.....	Jacobsville.....	Jacobsville.
<i>Huron County:</i> Cleveland Stone Co..... Wallace & Sons.....	Cleveland, Ohio..... Port Austin.....	Grindstone. Port Austin.
<i>Monroe County:</i> Strouse, J. D.....	Ottawa Lake.....	Ottawa Lake.

## TRAP ROCK PRODUCERS, 1913.

Operator.	Office.	Quarry.
<i>Marquette County:</i> Durocher, T. L..... Lipsett & Sinclair..... Marquette Stone Co..... The Park Cemetery Stone Co.....	Marquette..... Marquette..... Marquette..... Marquette.....	Marquette. Marquette. Marquette. Marquette.
<i>Houghton County:</i> Winona Copper Co.....	Winona.....	Winona.



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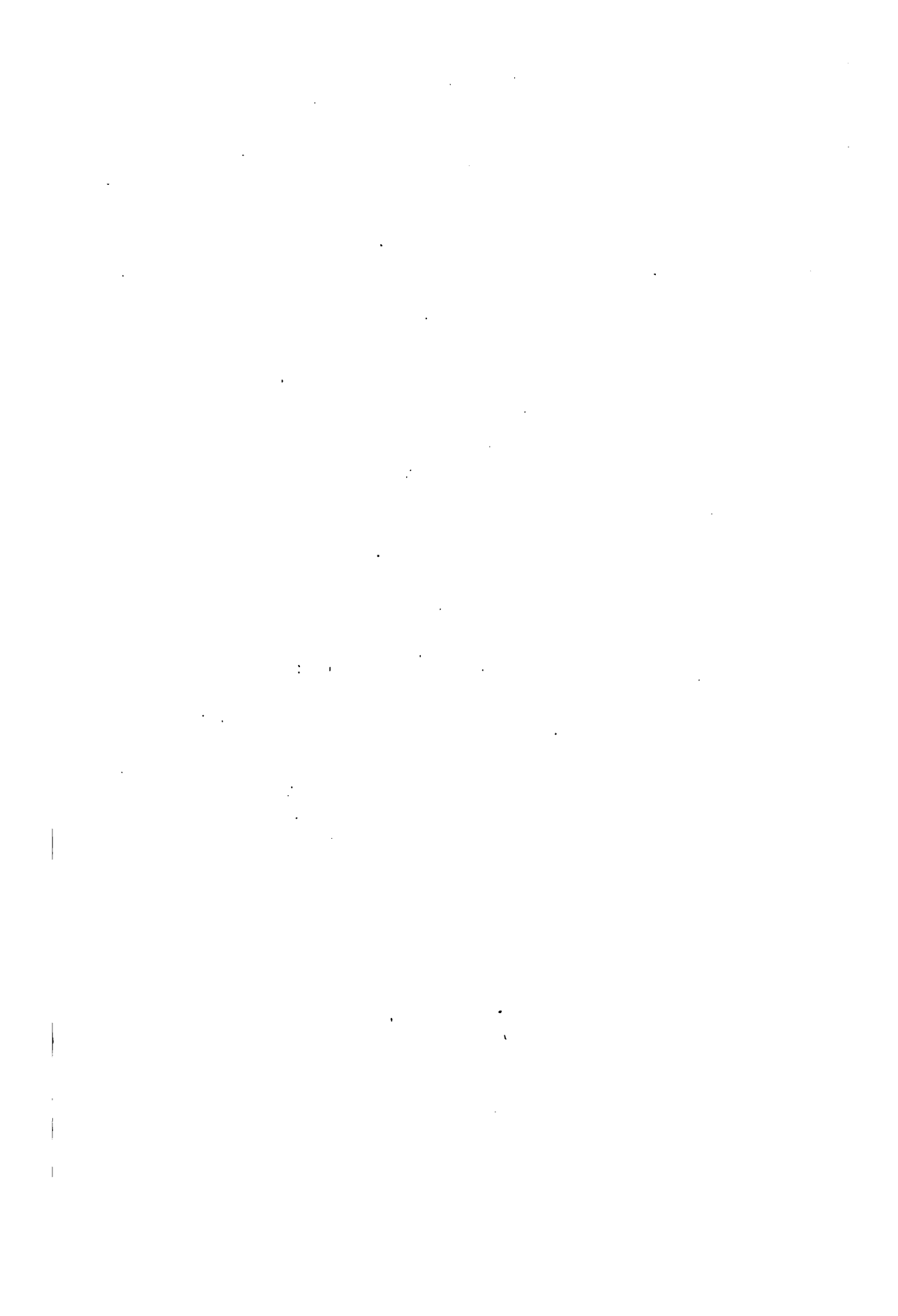
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